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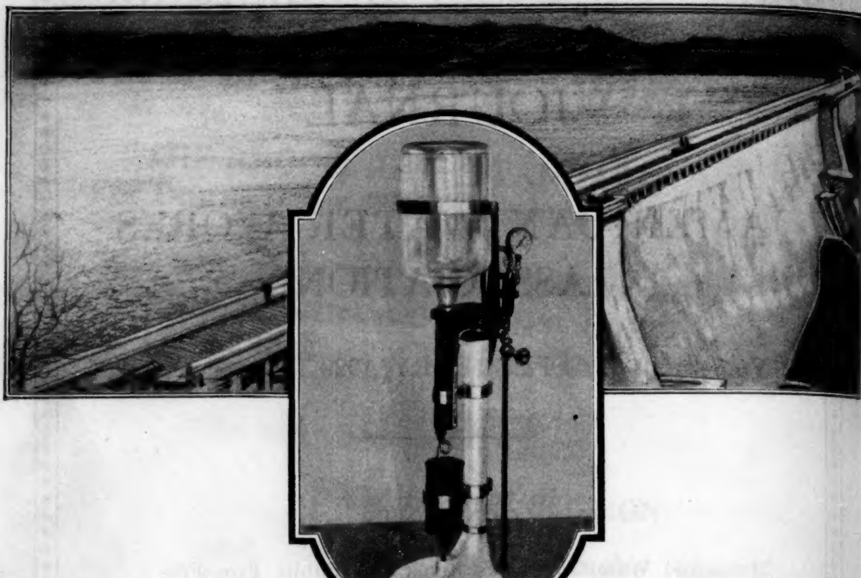

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MUNICIPAL WATER WORKS SYSTEMS AND PUBLIC FIRE PROTECTION[1]

BY CLARENCE GOLDSMITH[2]

Progress and development along engineering and scientific lines in this country during the past two decades have been more rapid in each decade than they have been in any previous century. The advancement in the various arts has been due to investigation and research carried on in well organized channels by technically trained experts. The progress in water works engineering has been in many respects, as pronounced as in other lines, and has not been due entirely to scientific endeavor, but to a considerable extent to the coöperation of various interests, including not only those engaged in designing and operating, but those utilizing the service.

A review of the JOURNAL OF THE AMERICAN WATER WORKS ASSOCIATION for the ten years prior to January, 1924, during which period the JOURNAL was published every other month, shows that the subject of fire protection occupied a relatively small space, one or two papers a year having been delivered before the Association. For the past four and one-half years, during which time the JOURNAL has been published monthly, the Association has devoted considerably more attention to fire service problems. The questions of quantities of water required for fire protection, desirable pressures,

[1] Presented before the Missouri Valley Section meeting, October 2, 1928.

[2] Assistant Chief Engineer, The National Board of Fire Underwriters, New York, N. Y.

pumping capacity and storage required for fire protection, carrying capacity of distribution systems, hydrants, including their distribution, connections to systems furnishing private protection, emergency connections, including polluted supplies, and charges for fire protection have been discussed in detail and at length by consulting engineers, superintendents, and fire protection engineers.

After carefully reviewing the subject matter of these papers, the speaker approaches the task of discussing the relation of municipal water works systems to public fire protection with some degree of hesitancy for fear of repetition. Nevertheless, there are some questions on which there is not a complete unanimity of opinion by all the interested parties, and some others which many of us at least feel have not been definitely and satisfactorily brought to a proper conclusion.

NECESSARY QUANTITY FOR FIRE FLOW

There is little diversity of opinion regarding the quantity of water which should be available from a distribution system for fire protection. The first full discussion of this subject was presented to the Association by Metcalf, Kuichling and Hawley in 1911. In 1916 The National Board of Fire Underwriters published a formula in their "Standard Schedule for Grading Cities and Towns of the United States with Reference to their Fire Defenses and Physical Conditions" based upon data secured in connection with their engineering investigations in over 300 of the larger cities of the United States. This formula has been presented and discussed before this Association and is now generally accepted as a standard for determining these requirements; it appears in our manual, "Water Works Practice." The first issue of our 1924 JOURNAL contains a discussion by Siems and Biser, including formulas for determination of the fire flow about groups of buildings of various sizes, heights, and construction.

The burden of providing sufficient capacity in the supply works, supply lines, and arterial mains to deliver the required fire flow in larger cities having populations in excess of 200,000 is negligible. The principal problem is to provide distributing mains of sufficient capacity to enable the flow to be concentrated. The capacities available must be able to deliver the required fire flow when the prevailing domestic consumption is at the maximum daily rate.

The City of Indianapolis furnishes a good example of a city having

a population of between 300,000 and 400,000, having a water system capable of furnishing satisfactory domestic service. The average daily consumption is approximately 35,000,000 gallons and the maximum daily consumption is about 55,000,000 gallons. The fire flow required is at the rate of 23,000,000 gallons; therefore, to meet satisfactorily the fire flow requirements, the system should be able to deliver these at the time of maximum daily domestic consumption, or at the rate of about 78,000,000 gallons. As a matter of fact, the maximum hourly rates observed on the system during sprinkling hours in the summer are approximately 110,000,000 gallons; therefore, it will be seen that the combined maximum daily rates and the required fire flow are considerably less than the rate at which the system can deliver.

The fire flow requirements in the smaller cities, towns, and villages, however, assume increasing relative importance as the populations lessen. For instance, a city having a population of about 20,000 has an average daily consumption of 2,000,000 gallons, a maximum daily consumption of 3,000,000 gallons, and a required fire flow at the rate of 6,500,000 gallons, which gives a total required delivering capacity of 9,500,000 gallons, while the maximum hourly demand does not exceed 4,000,000 gallons. Even greater discrepancies will be found as populations decrease.

In the days of the steam fire engine it was more economical and considered more reliable to raise pressures on distribution systems in order to develop sufficient pressure to deliver fire streams. During this epoch steam-driven pumps were used almost exclusively, there being only an occasional water power driven pumping station, and once in a while, an electrically-operated station, but the latter were rare. The raising of pressures on the smaller systems did not present any particular problem because in such direct pumpage systems the prevailing rate of domestic consumption would generally be much less than the capacity of the pump in operation. This is not true, however, in the case of larger systems. For instance, assume a system in which the prevailing rate of domestic consumption is 10,000,000 gallons and the pump operates under a domestic pressure of 50 pounds. Upon receipt of an alarm of fire the pressure would be raised immediately to 100 pounds and the domestic consumption would rise immediately from 10,000,000 to about 15,000,000 gallons, and this before the fire department was able to draw any water from the system. In other words, the pumping plant would

be called upon to deliver one and one-half times as much water at twice the pressure, which means that the draft on the steam plant would be three times that under ordinary domestic consumption conditions.

In order to be prepared to maintain fire pressure over any considerable length of time and supply any water for actual fire fighting it would, therefore, be necessary to have sufficient boilers in operation to meet the demand on them, and running a steam boiler or boilers so much below their rated capacity is not economical. Today, the gasoline engine driven motor pumper has reached such a degree of perfection that its reliability approaches that of the pumps in any pumping station, whether steam driven or electrically driven. It can be maintained and develop sufficient pressure for fire fighting at much less cost than pressures could be raised on the water system. In addition to this advantage, the danger of bursting pipes, rupturing plumbing, and blowing out connections at the very time when pressure is most needed is obviated. For the foregoing reasons the present accepted practice is to provide sufficient pumper capacity and not raise fire pressures.

A pressure of 75 pounds is generally considered necessary to develop small fire streams from hand hose lines, and it is desirable to be able to do this so that the first fire company responding can get into action before the fire has gained headway. Taking this into account, together with the prevailing heights of buildings, a pressure of from 60 to 75 pounds is now considered desirable domestic pressure to carry.

In the larger distribution systems where the pumps are located some distance from the high-value mercantile district, it is customary to maintain a pressure at the pumping station sufficient to maintain a certain predetermined pressure, say 65 pounds, in the mercantile district at all times. This necessitates raising the pump pressure during periods of maximum consumption and permits it to be lowered during the night when consumption is at a minimum.

During the war, and immediately thereafter, some water superintendents endeavored to practice economy by lowering the pressure during the night below that required during the day and below the pressure needed to supply private fire protection equipments. In order that an automatic sprinkler system may function properly, it is necessary that the pressure be such that when 500 gallons of water a minute is being drawn through the system there will be a

pressure of 12 pounds under the roof or on the upper line of sprinklers. In order that protection from private standpipe equipment may be effective, a pressure of 25 pounds on the highest hose outlet must be provided when 100 gallons of water a minute is flowing. Such equipments are generally only installed after tests have been made under normal domestic consumption conditions, and if pressures are dropped lower than this during the night, the protection to the property thus equipped is removed.

It is not uncommon to find buildings protected with automatic sprinklers located at points on the distribution system where increased consumption demands have brought about a reduction in pressure below that which was observed at the time of their installation, and in such cases this drop in pressure should be corrected by the installation of additional supporting mains in the vicinity, for any large drop in pressure is bound to result in an unsatisfactory supply for domestic use, particularly in the upper stories of buildings in the vicinity.

PUMP CAPACITY AND STORAGE

Pumping capacity and storage in connection with the fire prevention problem, in common with the problem of supplying domestic supply, may well be considered under one heading. In direct pumpage systems the adequacy and the reliability of a supply are directly dependent on the number and capacity of the pumps in service. A sufficient number of units should be provided to permit the maximum daily rate, plus the required fire flow rate, to be delivered with two units out of service in order that complete reliability may be secured.

In order that this may be done, proper thought should be given to the capacity of the individual pumps, and this is particularly important when additional pumps are being installed in an existing station. In years gone by there have been many instances where pumps of much larger capacity than was economically desirable were installed, but such errors in engineering judgment are not so common today. A much less pumping capacity is needed where any considerable amount of elevated storage is provided. The question of the value of elevated storage has been brought to the forefront in the last few years by the erection of elevated steel tanks of large capacity. Such tanks on works supplying systems on which there is large consumption do not materially reduce the number and capacity

of the pumps required. Such tanks, however, do make for economic operation and materially improve the quality of the domestic service when properly located.

As a basis of computing desired elevated storage, it is customarily assumed that one or two pumps may be out of service for a period of five days during maximum consumption conditions, and sufficient storage should be provided so that ten hours' fire flow would be available during the last ten hours of the five-day period. In giving credit for elevated storage, consideration must be given to its availability, both in analyzing conditions in the existing works and in planning new works. Occasionally large elevated reservoirs have been constructed and connected to a distribution system by pipes of such size that their capacity could not be delivered into the distribution system at rates sufficiently large to utilize the water held in storage.

FIRE FLOW TESTS

The quantities of water required for protection must be delivered throughout the distribution system so that they may be available about the group or groups of buildings which are to be protected. This necessitates the minor distributors of the distribution system's having a sufficient capacity to deliver the water required within a relatively small area without undue local friction loss.

The speaker presented a paper dealing with distribution system requirements in towns having populations of 2,000 or less, which appeared in the October, 1924, JOURNAL. Although calculations of the carrying capacity of gridirons in extensive distribution systems can be made with a fair degree of accuracy, the best and most accurate results can be obtained by making flow tests. Mr. George W. Booth, read a paper entitled "Methods of Making Flow Tests and Their Value to Water Works Engineers," which was published in our October, 1924, JOURNAL. In the course of the investigations made by engineers of The National Board of Fire Underwriters a considerable number of flow tests are made in each city inspected in order to determine the quantities of water available for fire protection in various sections of the city. These tests are used as a basis in recommending additional arterial feeders and the strengthening of the minor distributors where deficiencies are found. Water works engineers in general are making more use of this method of analyzing the carrying capacities of their distribution systems from year to year. Several years ago, George H. Fenkell, made a complete

survey of the distribution system of the City of Detroit by laying out tests including all hydrants on the distribution system. Four hydrants were opened at each test and the residual pressure was observed on a fifth hydrant. With this information at hand it was a comparatively easy matter to lay out reinforcing mains to provide an adequate supply for fire protection in all sections of the city. After the additional mains had been laid, as planned, the tests were repeated and the results showed that the desired increase in carrying capacity had been obtained.

LOCATION AND NUMBER OF HYDRANTS

The proper location and the installation of a sufficient number of hydrants are problems which should receive careful study, for, although a distribution system may have adequate carrying capacity to furnish the required fire flow, it frequently can not be utilized on account of the lack of hydrants or their improper location. "Water Works Practice" contains a discussion of hydrant distribution, both in the text and in the appendix. Unfortunately, in the early days before the subject of hydrant distribution had been given sufficient study, their distribution was referred to as "hydrant spacing," and today it is frequently referred to in units of lineal spacing, whereas the area served is the only proper unit to use. For instance, the city blocks in the Portland, Oregon, mercantile district are 200 feet square. One hydrant at each street intersection, therefore, gives a satisfactory hydrant distribution of one hydrant to each 40,000 square feet, the lineal spacing in this case being 200 feet. In Salt Lake City, Utah, the blocks are approximately 700 feet square, making the area of each block 562,500 square feet; therefore, 14 hydrants per block are required to give a hydrant distribution of one hydrant for each 40,000 square feet. This would require the installation of hydrants in such a manner that the lineal spacing would be 87 feet.

The general subjects already touched upon are ones on which there is in general almost complete agreement among all parties concerned. Several subjects on which there is a diversity of opinion will now be touched upon in order that these questions may again be brought to your attention for further study and discussion.

PRIVATE FIRE PROTECTION SERVICE

In the major portion of the cities in the United States there is little question in regard to the size of the connection provided to serve

private fire protection equipment. Occasionally, however, those responsible for the operation of the works oppose the installation of connections large enough to serve the equipment to be installed. This general subject has been under consideration by a standing committee of the National Fire Protection Association for the past twenty years, and the rules formulated by this committee are complied with by a large majority of engineers and superintendents. These read as follows:

The conditions in isolated risks are so different from those in city buildings that it has been considered better to cover the two cases separately.

Isolated risks

1. Permit 4-, 6-, and 8-inch service connections into yards, and in special cases larger ones where conditions warrant, and where more water is available and is needed for the best protection.

Connections of the larger sizes are only permitted on the ground that every such connection has an easily accessible controlling valve as required by Section 2.

2. Every service connection into the property to have an outside gate-valve located where it will be accessible in case of a fire in the property.

Accessibility means that the valve must be so placed that it can be easily and surely gotten at and operated under any condition of fire which could occur in, or about, the protected plant.

Generally in such properties there is ample yard room so that the valve can be placed well away from all important buildings and an indicator post provided.

Where this is not feasible there is usually a solid tower, section of blank wall, or other protected section, against which the valve can be placed and safely shielded.

In a few cases it may be necessary to build a fire-proof valve room and provide access to it which would be safe under any conditions.

The local conditions should be studied in each case of this kind and the arrangement best fitting the special surroundings adopted.

3. Every connection over 2 inches in diameter from the yard mains into buildings to have an outside valve located where it would be accessible in case of a fire in the building.

This applies mainly to connections for sprinklers or hose standpipes, but also would apply to any connection over 2 inches for manufacturing or other purposes. Valves on such connections cannot always be located as safely as those on the main service connections required by Section 2, but should as far as possible be located with the same ideas of accessibility.

4. All such controlling valves larger than 2½-inch to have indicator posts, or, where posts are not feasible, to preferably be located in valve wells, the gates to be of the outside screw and yoke pattern, and the location of all such valves to be plainly marked by signs which will be always visible.

City risks

1. Four-inch service connections to be used for smaller equipment, where this size of pipe will furnish ample water for the equipment.

2. Six-inch connections to be permitted where the size of the equipment requires more water than a 4-inch can deliver.

Where the sprinkler systems can be designed in two or more sections and the arrangement of buildings permits taking connections from different street mains, or from well separated points on the same main, it is better to provide two or more 4-inch connections, each supplying separate and independent sections of the system, where this can be done without unduly increasing the cost or decreasing the efficiency of the sprinkler system.

This reduces the chance of one break causing a serious waste of public water, or an interruption of service to more than one section at a time. Where pressure is high and mains large, 4-inch services will often supply ample water; where pressure is low or mains small, larger services are necessary to bring enough water to give efficient sprinkler protection.

Where in city risks the controlling valves required by Article 3 are favorably located so that they would be accessible and likely to be properly handled in case of fire, 6-inch connections could more freely be permitted.

3. All such service connections to have outside controlling valves in one of the following ways:

a. At the curb line with an indicator post.

b. At the building line with an indicator post set in a recess in the building wall.

c. In a valve pit near the middle of the street, or at the curb if a cover in the street is liable to be obstructed by snow or ice.

d. In bad cases, the connection may be looped back and the indicator post or valve pit set on the opposite curb across the street from the building protected; or the connection may, in some instances, be offset so as to come opposite an adjacent building rather than the one supplied.

e. Frequently the controlling valve can be placed opposite a stair tower or a division wall, where there is the least chance of falling walls making it inaccessible.

f. A hand wheel should be kept on each valve, and valves of the outside screw and yoke type should preferably be used.

Street mains should be so gated that in case of necessity not more than a block length, or a maximum of 500 feet of main will be shut off.

4. All valves on fire services to be plainly marked with the direction to turn to open, size of service, and what it controls.

This marking can go on indicator posts where they are provided. Where the valves are in the ground plain signs should be put on adjacent building walls, giving also the distance in feet to the valve. It is probable that some uniform sign in wording and color can be developed for any one city which would be recognized wherever seen. It may further be possible to have a standard adopted for use in all places, thus giving the quickest recognition to such valves.

5. All manufacturing connections above 2-inch to be similarly provided with gates.

6. In cities having a number of buildings protected by sprinklers a small squad of intelligent men should be organized to handle the valves in case of fire under the direction of the chief of the fire department.

This squad could be formed either from the fire or water department, or possibly from both. With the growth of automatic sprinkler equipments it is necessary to have an efficient body of men who will understand the value of sprinklers and the best method of handling them to take charge of these matters at severe fires. The fullest use of private protection requires in cities that valves be cared for by men who especially understand the whole system and who will work in full conjunction with the public department.

It is recognized that large connections into buildings from the street mains of a municipal water system may, in case of a large fire, prove a very great detriment, if they were broken off, and would put the system out of commission. In all conflagrations on record the wastage of water has been very large, but this condition would be true in a conflagration even though there were no excessively large openings. A study of fires extending over the past twenty years shows that the danger of bleeding water works systems by broken connections is almost entirely lacking when these services are used only to supply automatic sprinklers.

Whatever difference there may be on this subject appears to be due to the fact that it has been discussed in general and hypothetical terms rather than in specific terms. The engineers and inspectors connected with the fire insurance business are vitally interested in automatic sprinklers and their connections. For this reason it is believed all water works officials will acknowledge that this class of large service connections is the least troublesome of any. Automatic sprinklers are one of the greatest benefits to the country from an economic standpoint, and it is only through the use of such equipment that many of the present very inferior buildings can be made fire-safe. It is recognized that the destruction of one plant in many instances means the wiping out of the livelihood of an entire community.

Our Association has placed itself on record by establishing a separate Fire Prevention Section, and our members in most cases take a broad viewpoint of their obligation to furnish fire protection. For the average city, assuming that there are no sprinkler connections, there would be certain requirements for fire service, and no single instance is known where these fire protection requirements would be increased by the addition of automatic sprinkler systems in the community.

EMERGENCY SUPPLIES

From year to year the American water consumer has been demanding a better quality of water for domestic use. Our well organized State Boards of Health safeguard the quality of the supply furnished by regular supervision, and anyone today touring across the continent can feel absolutely safe in drinking water drawn direct from any municipal system. Many water plants maintain water in storage in large or small quantities immediately available for emergency use. Such water when under the direct supervision of the water works officials is maintained continually in potable condition.

During the last century such scrupulous care was not given to emergency supplies and many connections were made from such supplies when they were polluted. A water works man today takes an entirely different view of the matter, and these connections are rapidly being removed with the support of the several State Boards of Health. Many of these polluted supplies were made available solely for fire protection purposes and there is still a feeling among some few that such connections are now approved by the underwriters' engineers.

The National Board of Fire Underwriters is a voluntary organization of two hundred and twenty stock fire insurance companies. Their Chief Engineer, one of our members, George W. Booth, has from time to time gone on record on this subject, and it may not be amiss, so that there may be no further misapprehension, at this time to state his views, which are accepted and followed by the companies of the organization which he represents:

> The engineers of The National Board of Fire Underwriters do not, and we believe other engineers should not, favor such connections, but there are cases where they have already been made, and it is not possible, without the charge of discrimination, to refuse credit for them as emergency sources. It is, however, standard practice with many of the insurance bureaus to recommend secondary sources of supply which will be safe, as, for instance, a storage reservoir.

In connection with our city inspection work done by our own engineers and by engineers of the several rating bureaus, close relation is maintained with the State Boards of Health in many states, and our reports are placed in their hands so that they may have available any information which may be of interest to them. In the application of the Standard Grading Schedule to determine the class of fire protection, credit is given for polluted emergency supplies only when

we are furnished with a signed statement from responsible city authorities that the supply will be utilized as soon as there is any shortage in the regular supply.

CHARGES FOR FIRE PROTECTION

The last general topic to be discussed will be that of charges for fire protection, and on this subject there seems to be a greater diversity in practice and in opinion than upon any other points which have been touched upon. The financial structures of few water works provide for the proper allocation of the cost of fire protection. One has only to review a tabulation of the hydrant rentals charged in different cities to be convinced that the revenue from this source has little, if any, relation to the actual cost of furnishing fire protection. Some of the more recent franchises granted private water companies do, however, provide in a fairly equitable manner for revenue from this source in proper proportion.

In these days of budgets, conservation, and efficiency, each municipally owned water system should be run on the same financial basis as it would be run if it were a private corporation. There is no valid reason why the water rates for domestic purposes should cover, in whole or in part, that portion of construction and operation expenses which are directly due to fire protection.

Five years ago Earnest C. Willard of Portland, Oregon, made a very complete analysis of the cost of construction and operation of the water system supplying Portland. The system was divided into zones and after the fire protection requirements had been determined, the various charges were divided between the domestic and fire protection service. Similar divisions were made in the cost of construction and operation of the supply works and the general operating expenses. The final division showed a distribution of 77.9 per cent for domestic service and 21.1 per cent for fire protection. At this time the City of Portland had a population of about 300,000. Mr. Willard's figures correspond very closely with the general percentages of the costs of the two services given in "Water Works Practice."

It is hoped that this matter will from now on receive the attention which it deserves so that eventually all of our water works systems will secure adequate compensation for the fire service rendered, and have it come from the proper source, which unquestionably would be from a general tax levy based on property valuation. When rates for public protection have been equitably established, the munici-

pality or the private company will receive proper compensation for such hydrants, large pipes, pumps, storage reservoirs, elevated or ground, which are required in excess of those required to furnish domestic consumption. This protection will be paid by the individual property owner, and this having been done, the proper compensation is provided for the service given, and in case of fire in any building without private protection, its extinguishment will be undertaken by the fire department which takes water from the hydrants provided and paid for. Such conditions require the response of four engine companies and two ladder companies in our larger cities, and in case the fire involves a considerable portion of any large building, additional fire companies, frequently as many as twenty or thirty, are required to cope with the fire. There appears to be no equitable reason to make any charge for a service connection to supply private fire extinguishing equipment beyond a nominal charge to cover the actual cost of maintenance of the connection as the delivery of the water to the property has already been paid for by the taxes levied for the public protection.

In order to analyze all the benefits which accrue from the installation of private protection appliances, such as sprinkler equipments, a city block of the character ordinarily found in most of our cities will be considered. The buildings in the block consist of a moderate area, 10-story, fireproof building exposed by an excessive area, 5-story, joisted-brick building adjoined by a 4-story building of small area, of similar type of construction, which general types of buildings occupy the remaining area of the block. The excessive area, 5-story building exposes some of the latter type of buildings across a narrow alley. This excessive area building has paid its proportionate share for protection furnished both by the water and the fire departments. A fire in the building may call for a fire flow as great as 10,000 gallons a minute, and the response of twenty engine companies. The building is a conflagration breeder and the buildings exposed all have a charge for the exposure hazard included in their insurance rates, and if the conditions in the block as a whole offer a hazard distinctly greater than normal, this fact will be reflected in determining the classification of the protection of the city.

It is true that the benefits resulting from the installation of a sprinkler equipment in this excessive area building of inferior construction will result in a material reduction in rates to the owner or occupant, who will have been put to a considerable expense to install this protection, but considerable benefit will be enjoyed by other prop-

erty owners in general because of the added protection. The exposure charges to the other buildings in the block will be reduced or entirely removed. The hazard in the block will be reduced with the result that no consideration will be given in the application of the Standard Grading Schedule for the hazard which existed before the added protection was installed. The probability of requiring large quantities of water and heavy fire department response, both of which would materially reduce the protection of other property in the city in case of fire in the building under consideration, would be reduced to a minimum. All expenses of installing connections to the street main, including a meter, if required, should be borne by the parties installing the private equipment, but no further charges beyond a reasonable maintenance charge appear justified.

If the financial set-up of the system is such as to provide proper revenue for fire protection, additional so-called "readiness-to-serve" charges for private equipment, if put into effect, would result as follows: The owners of all property, if none has private protection, will pay for public protection a certain proportion of the taxes on their property which will be based on the assessed valuation, say 3 per cent. Then, if a sufficient number of buildings are equipped with sprinkler equipments and standpipes, the proportion which unprotected properties will be required to pay will be reduced, say to $2\frac{1}{2}$ per cent of the taxes paid, while the privately protected properties will pay in addition to the $2\frac{1}{2}$ per cent of their taxes which will cover the public protection, a sufficient amount for private protection to make this general reduction of one half of one per cent possible. This will result in the sum paid for public protection, plus the special assessment for private protection, exceeding the amount paid before the private protection was installed, while the unprotected property will be enjoying a reduction in cost of protection at the expense of the owner who has installed equipment at his own expense. In plain equity, the owner of the unprotected risk is receiving an entirely unjustified benefit for it is his property which still makes it necessary to maintain a powerful fire department, provide large quantities of water, and makes sweeping fires probable.

The progress made by members of this Association and others associated with water works operation in properly appreciating the relation of public fire protection to the municipal water works system has been consistent and continuous during the past two decades and without question has been due principally to the papers and discussions presented before our Association.

FINANCING EXTENSIONS OF WATER MAINS[1]

By N. B. Jacobs[2] and Charles L. Fox[3]

At the October, 1925 meeting of the Pennsylvania Water Works Association, W. C. Hawley, Chief Engineer of the Pennsylvania Water Company, presented a review[4] of the decisions of courts and commissions and the general practice of water works in regard to extending service into partially remunerative territory. That paper brought out a diversity of opinion in the decisions of the various regulatory bodies dealing with this problem. In only two states, namely, New Jersey and Oregon, were definite rules stated which gave an indication, at least, as to the requirements and stipulations under which the extension could be considered mandatory. A mathematical determination of an equitable apportionment of cost between utility and consumer was presented by Mr. Hawley. Sufficient check on this rational method of allocation is not available at this time. However, additional studies and tests based upon the decision upon average extension cases should prove the reasonableness of this method.

The discussion of this paper reviewed the results of a questionnaire sent out to approximately 100 water companies in Pennsylvania requesting data in relation to extension agreements. It is interesting to note that, of the 50 companies indicating a definite policy, approximately 50 per cent required deposits which would later be refunded. So much dissatisfaction has been experienced with guarantee agreements, after they have run for some years, and properties have changed hands, that the practice has undoubtedly changed to require a cash settlement with provision for either complete or partial refunding as the business along the extension is developed. Generally, there is a limit as to the period of time during which refunds are to be made.

[1] Presented before the San Francisco Convention, June 15, 1928.

[2] Vice President and Treasurer, Morris Knowles, Inc., Pittsburgh, Pa.

[3] Assistant Superintendent, Pennsylvania Water Company, Wilkinsburg, Pa.

[4] Proceedings of the Pennsylvania Water Works Association, 1925, page 70.

The New Jersey Commission seems to be the only one which has laid down a general rule outlining conditions under which water companies must make extensions and to which applicants for extensions must conform. The rule which the New Jersey Commission has recommended for adoption by water companies generally, provides that where extensions of mains are desired by those engaged in the development of real estate, but who are not interested in permanently residing in the dwellings being built, the full cost of the extension shall be advanced or loaned to the water company by the real estate promoters and that later they shall be reimbursed by the water company when the buildings are occupied by bona fide consumers. The amount that shall be returned to them shall be at the rate of $3.50 for each $1.00 of annual revenue. If there are properties to be supplied which are already occupied the amount to be advanced shall be the cost of the extension less $3.50 for each $1.00 of immediate revenue, the balance to be returned at the same ratio as additional consumers take service from the extension. The New Jersey Commission has gone so far as to say that a water company should not depart from this rule:

". . . . in a case where a tract is so laid out by the promoters that the maximum number of customers which may be served from the mains is too small to bring to the company the amount of revenue required to support the necessary investment and the promoters can never expect to have returned to them the entire amount advanced." "If this tract is so laid out by the promoters that the maximum number of customers which may be served from these mains is too small to bring to the company the amount of revenue required to support the necessary investment, it is not a matter for which the water company can be held responsible." (Parker and Krewson v. Merchantville Water Company, P. U. R., 1924, C-461.)

The Oregon Commission has said that the general rule for water utilities is

"that no extension of mains should be made that does not allow a reasonable chance of yielding an annual revenue of 8½ per cent on the investment in mains in addition to at least 5 cents per 100 cubic feet of water delivered, plus the proper consumer costs . . . . . Otherwise such extension would prove a burden on the already existing customers and tend to increase their rates." (P. U. R., 1918, A-649.)

In the above the Oregon Commission recognizes a principle which was laid down by the Wisconsin Commission in the Sand Rock Water Company case, P. U. R., 1921, C 141, in which the Commission said,

"this Commission has frequently pointed out that a utility cannot extend its mains or other service lines indefinitely to reach a single new consumer or small group of consumers and at the same time furnish service to all at the same average unit cost. In the past it has been considered necessary, therefore, to establish some rule or rules fixing equitable terms under which extensions of pipe or other lines will be made for new consumers beyond the limits of the utility system or to make frequent readjustments of rates to all consumers to fit the changed conditions. There seems to be little, if any, ground on which to adopt the latter in preference to the former plan in most cases."

The New Jersey rule seems to be unusually liberal to the water company. The Oregon rule appears to be fairer and more capable of application without causing any question of discrimination.

A review of the decisions on extension cases since 1925 indicates that it is still the general policy of various commissions to deal with each individual case on its own merits. However, the Wisconsin Railroad Commission has re-approved the application of a definite formula set forth in the decision of the Sand Rock Water Company v. Fonddulac, P. U. R., 1921, C 141. In F. W. Hennessy et al., v. Village of Highland, P. U. R., 1926, E 821, this Commission approved the following rule:

"That extensions of existing water mains will be laid for applicants for water service at the expense of the Village for a distance not in excess of 50 feet for each new customer along the line of such extension, measurement beginning at the line of the cross street. Where the extension desired is in excess of 50 feet per customer, then such extension will be made by the Village after the applicant or applicants for the water main extension advance to the Village the cost of such extension in excess of the sum of the cost of the 50-foot extension for each of the orignal applicants, the Village to refund to the party or parties making the advance the cost of a 50-foot front extension for each additional customer tapping said main until said full sum previously paid to the Village has been refunded without interest."

The Wisconsin Commission in handing down this decision seems not to have added the cost of service lines and meters to the total cost of the extension. Meters and service lines increase the cost of an extension from 30 to 65 per cent depending upon the length, size and material of service line. This is a financial burden that should be included when the cost of making a main line extension is being considered.

Another rule of rather general application is indicated by the California Railroad Commission in the case of the Town of North

Sacramento v. North Sacramento Light and Power Company, P. U. R., 1926, C 601, as follows:

"The Commission has found that under average conditions an extension of a pipe line to serve a new territory does not become compensatory until the revenue received from the sale of water therefrom for 12 consecutive months equals 25 per cent of the cost of the extension and of the services and meters attached thereto. Such a revenue is necessary to cover maintenance and operating expenses, depreciation, a return on the investment in the extension, and also the cost of producing the water and conveying same through the system to the point where it enters the extension."

This rule was virtually adopted by the Indiana Commission in Indiana Power and Light Company (P. U. R., 1925, C 8).

The development of a rule of thumb method for the determination of the advisability of a utility extension into undeveloped territory tends naturally toward making the most safeguarded investments. However, where hard and fast rules have been adopted, the discretionary powers of the utility cannot be exercised, so that such rules might represent the maximum contribution for the applicant. In the dismissal of the case of Borough of Emsworth v. Ohio Valley Water Company, P. U. R., 1927, D 371, the Pennsylvania Commission includes the following excerpt from the recent opinion of the Pennsylvania Superior Court in Sherman v. Public Service Commission No. 181, October Term, 1926, in which the Court affirmed the Commission in declining to order a desired extension of water service:

"We are not to be understood as holding that the extension of service of a public utility is dependent on the profit which may reasonably be expected therefrom; in proper cases such extension may be ordered though the immediate results of the expansion may entail financial loss to the company; but the company should not be subjected to unreasonable expenditures, nor the consuming public be unduly burdened, because of the overdevelopment or premature development of scattered sections of the city in advance of its normal growth, when there is no rational expectation of the event justifying the expenditure."

The development of a stated principle, quite general in form, for the making of extensions has recently been attacked by the Pennsylvania Public Service Commission. The Rules and Regulations of the Clearfield Water Company included the following:

"The Company will extend its mains of proper size considering future growth and additions within its chartered territory on public roads, streets and lanes, upon application, when a resonable revenue is assured."

The Commission in its decision on rates, P. U. R., 1928, B 640, took occasion (although the question of extensions was not raised in the proceedings) to state:

"Rule 37 provides that the company will extend its mains of proper size considering future growth and additions within its chartered territory on public roads, streets, and lanes upon application when a reasonable revenue is assured. This rule has no place in the rules and regulations, which provide a working basis for company-consumer relationship and until service is initiated, no such relationship exists. For this reason, the rule should be eliminated."

The elimination of a rule or general principle for extensions from the rules and regulations of utilities can have no other effect than to put this phase of the business on a separate and individual basis for each specific case.

An analysis of the decisions of commissions on this subject prior to the last few years indicates a tendency to decide more often in favor of the applicant than for the utility. Several of the decisions in such cases have been predicated on sympathy rather than on financial reasonableness. A review of decisions since 1925 indicates a more businesslike attitude in dealing with this question.

In some twenty-three extension cases, all reported in Public Utilities Reports Annotated, the complaints were dismissed in eighteen instances or almost 80 per cent of those tried. These cases are summarized in table 1.

The Pennsylvania Commission allowed an extension at the request of the Utility in spite of protest by the municipalities already supplied that such extension was unremunerative and would be a burden to the two boroughs already supplied. However, the Company agreed that rates in these boroughs would not be affected if the extension failed to be self-sustaining.

On appeal to the Superior Court, that Court, in reversing the Commission, stated (Borough of Clark Summit v. the P. S. C., 17, P. C. R. 1):

"While the Commission has found that the granting of the application was necessary and proper for the service, acommodation, convenience and safety of the public, and we cannot say that there is no competent evidence to support this finding, the conclsion is irresistible that the order was based in part at least upon the provisions and the stipulations that the capital expenditures made for service in the territory covered by the Waverly extension should be excluded from the rate base upon which rates in the two boroughs shall be

TABLE 1

Statistics relating to adjudication of applications for water line extensions

REFERENCE	JURISDICTION AND CASE	ACTION TAKEN	REMARKS
P.U.R. 1927 B 619	Wisconsin R.R. Com. City of Hudson	Dismissed	Municipality not required to make unprofitable extension. Cost $7,000.00. Domestic revenue $50.00
P.U.R. 1927 B 734	Massachusetts Dept. of Public Utilities Auburn Water Company	Dismissed	Cannot order long extension to school house when company cannot finance
P.U.R. 1927 C 344	Pennsylvania Public Service Commission Bangor Water Company	Sustained in part	Extension of 550 feet for 4 houses unreasonable. Extension cost $1,400.00 revenue $110.00, considered reasonable
P.U.R. 1927 D 372	Pennsylvania Public Service Commission Ohio Valley Water Co.	Dismissed	Cost of extension $4,500.00 Revenue, $166.00 per year
P.U.R. 1927 A 275	Mississippi Supreme Court City of Greenwood	Dismissed	Mandamus will not carry compelling city to extend connection for 700 feet since it is within discretionary power of city whether extension be made
P.U.R. 1926 E 260	Pennsylvania Public Service Commission Heidelberg Township Water Company	Dismissed	Extension to single consumer. Cost $550.00. Revenue $29.60
P.U.R. 1926 E 821	Wisconsin Railroad Commission Village of Highland	Dismissed	Commission finds rule allowing portion to be paid by consumer reasonable
P.U.R. 1926 C 155	Pennsylvania Public Service Commission Northern Cambria Water Company	Dismissed	Extension to three frame houses. Cost $1,500.00. Revenue $30.00

TABLE 1—*Continued*

REFERENCE	JURISDICTION AND CASE	ACTION TAKEN	REMARKS
P.U.R. 1926 D 298	Colorado Public Utilities Commission City of Rifle	Dismissed	No evidence of any surplus of water not needed in the city
P.U.R. 1926 B 626	Wisconsin Railroad Commission Village of Bloomington	Sustained	Cost of Extension $1,560.00 Nine residences along line
P.U.R. 1926 C 423	Washington Department of Public Works Lake Forest Light, Water and Power Company	Sustained	Partial payment by consumers
P.U.R. 1926 C 432	Wisconsin Railroad Commission Peoples Water, Light & Power Company	Dismissed	City voluntarily agreeing to pay increased fire protection rates to compensate for loss of revenue on unprofitable extension considered unreasonable
P.U.R. 1926 C 600	California Railroad Commission North Sacramento Light and Water Company	Dismissed	Cost of extension $13,500.00. Revenue $320.00
P.U.R. 1925 A 181	Wisconsin Railroad Commission Village of Waterloo	Dismissed	Extension not required unless applicants willing to participate in cost
P.U.R. 1925 A 388	New Jersey Board of Public Utility Commissioners General Water Supply Co.	Dismissed	Cost of extension $1,800.00. Revenue, $48.60. Complaint dismissed even though line is requested to be laid before paving
P.U.R. 1927 E 420	Pennsylvania Public Service Commission Roaring Creek Water Co.	Dismissed	Cost of extension $14,830.00 Revenue from 5 consumers

TABLE 1—*Concluded*

REFERENCE	JURISDICTION AND CASE	ACTION TAKEN	REMARKS
P.U.R. 1927 E 642	Pennsylvania Public Service Commission Orbesonia Water Co.	Dismissed	Cost of extension $1,430.00. Revenue $87.50
P.U.R. 1927 E 802	Pennsylvania Public Service Commission Allegheny Water Company	Dismissed	Cost of extension $800.00. Revenue $14.00. Offer by Company to lay main provided complainant dig trench refused
P.U.R. 1927 D 11	Pennsylvania Supreme Court Howard Sherman v. P.S.C.	Dismissal of application by P.S.C. sustained	Cost of extension $14,564.00, revenue $140.00
P.U.R. 1925 E 788	Pennsylvania Public Service Commission Johnstown Water Co.	Dismissed	Company not compelled to furnish service outside chartered territory unless it so elects to do
P.U.R. 1925 C 81	Indiana Public Service Commission Indiana Power & Light Company	Rule established	Company to make extensions when estimated permanent revenue for a period of 4 years equals cost of extension
P.U.R. 1925 C 187	Pennsylvania Public Service Commission Lansdale Water Co.	Dismissed	Company cannot be required to go outside of Charter Territory
P.U.R. 1926 D 161	Pennsylvania Public Service Commission Lewistown Reedsville Water Co.	Dismissed	Company cannot be required to make extensions for real estate development. Cost of extension $13,000.00, revenue from 27 consumers

based in the future. In our view, the stipulation filed was incompetent evidence which materially affected the determinaton of the Commission and an order which rests upon any such ground is not in conformity with law."

An agreeable financial arrangement, developed at an engineering conference, was completed recently in a proceeding before the Pennsylvania Public Service Commission in the case of John Demshar, et al., v. the Pennsylvania Water Company, 16 P. C. R. 146. This agreement provides that the cost of the extension amounting to $47,000.00 should be borne by the company and township in the amount of $28,900.00 and $18,100.00 respectively. The latter amount will be gradually repaid "when domestic consumers in excess of the number of one hundred and thirty (130) shall have been connected with respondent's mains, extended as herein ordered, the Pennsylvania Water Company, respondent, shall pay to said Township of Penn the sum of Forty-seven dollars ($47) for each consumer in excess of said number connected within ten (10) years from date such extension, and for each such consumer connected subsequent to said ten-year period, said respondent shall pay to said township an amount which shall decrease from said sum of Forty-seven dollars ($47) at the rate of Five Dollars ($5.00) per year or part thereof; provided, however, that said payments shall not in the aggregate exceed the sum of Eighteen Thousand One Hundred Dollars ($18,100)."

In a case where extensions have been asked to be made into unimproved territory, The Public Service Commission of Pennsylvania in the case of Franklin Culp, et al. v. The Roaring Creek Water Company, Complaint Docket No. 7234, July 12, 1927, has made the following ruling:

"Before the respondent should be required to extend its service on the street in question, the grade of the street should be determined by the proper officials and the street made to conform with the grade thus established."

DISCUSSION

J. E. Gibson (Charleston, S. C.): Mr. Fox has done the Association a great work in collecting the statistics and the decisions of the public utility commissions throughout the country, and giving us these citations for our own use later.

Every case, however, should be treated separately. In determining the return on extensions we often lose sight of the fact that a dollar put into the distribution system must earn a return, not only on the cost of that extension, but on the cost of pumping equipment, filter plant, buildings and boilers and the cost of developing the

water supply. The cost of developing a second supply to augment the original one is going to be greater than for the original supply, and so on, for the third and fourth extensions of supply. All of this cost must be taken into account. While you may have a surplus of water at the time any one extension is made, ultimately you must make an extension for additional water, because you are simply spending your principal or investment in your first supply of water.

Most of us, particularly now under rate commissions, know the relative cost of the various parts of our plant, that is, specifically, what we have invested in the distribution system. Therefore, we can determine the relation between the cost of distribution system and the cost of water supply and other equipment. It becomes a relatively easy matter to determine what ratio of income we have per dollar invested in distribution system to the total income that should be returned on the entire investment.

With this as a factor, I rather think that that means was used in determining the figure of $3.50 quoted by Jacobs and Fox in the New Jersey Public Utility Commissions findings.

In our case at Charleston, it worked out that we had to have a return of about 33 per cent. That is, if we invested a dollar in extensions of distribution system, we had to get a return on $3.30 to make the proposition pay. That was an allowance of about 8 per cent for water. We do, however, go a little bit further. If the line extends without the corporate limits of the city, we insist upon the development company paying the entire first cost of the extension. We do the work, buying all material and doing all the supervision and laying. If the extension does not pay within a period of ten years, the extension becomes the property of the Commission or the city without any further guarantee of return to the developing company.

The reason for that was that, if the land development did not prove a success in ten years, it was evidently a mistake and therefore the Commission and the people of the City of Charleston who owned the plant should not be penalized to the extent of returning capital to an investment that was doomed to failure, or had been a failure up to that time.

W. W. Brush (New York, N. Y.): The return that comes to a municipality through the extension of mains within its corporate limits, in the form of added value, and therefore added assessment,

is an indirect return on the extension. In New York the assessors take into consideration whether the water main is or is not in front of a property in determining its value. There is no direct return for the placing of the water main in front of the vacant property, but there is the indirect return to the city in the form of added taxes collected.

In New York State we have no regulatory commission. There is absolutely no control over rates charged in the distribution of water. Therefore, each one of us is at liberty to approach it in whatever way we see fit. In New York it has been our practice for a number of years past to extend our water main to the extent of 150 feet of water main, for a single family to be supplied, adding 100 feet additional for each family, and not to include the distance of the width of the street in the amount of pipe laid. We take up special cases, in accordance with the conditions and extend the mains to a greater distance than would be covered by the general limitations I have given, when it appears that a certain territory would be rapidly developed.

On the whole, the plan has worked out satisfactorily, both to the city and to the citizens. But what the city can do is a very different thing from what a private company can do which gets absolutely no return from the increased value of taxes.

As has been stated by Mr. Fox and Mr. Gibson, each case must be treated individually, but should be treated on some general plan so that both the company or the city and the consumer will know approximately the basis upon which an application for water main extension will be passed on.

W. J. Orum (Montgomery, Ala.): The City of Montgomery, Ala., has substantially the same law as Charleston. In new development of territory within the city limit, or without, the installation of the water system is paid for by the developer. In other words he pays for the pipe, the digging of the ditch and placing the pipe and caulking it. In fact, he pays for all the overhead.

At the end of ten years the line reverts to the city under ordinances. In the event fire hydrants are installed the developer pays for the hydrant and we install it. In the outlying districts, either within or without the city limits, he pays for the installation of the water.

WATER WORKS VALUATION FOR RATE MAKING PURPOSES[1]

By E. B. Black[2]

Valuations of water works properties for rate making purposes are ordinarily limited to those privately owned utilities seeking a greater return on property used and useful in the service, or those whose patrons are endeavoring to secure a readjustment of rates as between certain classes of consumers, or a revision downwards of all rates. Municipally owned and operated water utilities usually adjust rates by comparing them with rates in municipalities comparable in size, or by determining the income required to meet operating and maintenance expense, plus the cost of ordinary extensions, rather than by fixing a rate base based on a valuation of the property.

In the eighty-four years of public utility regulation started in 1844 by the setting up of Railroad Commissions in the States of New Hampshire and Rhode Island, the regulation of public utility rates has become so firmly established through decisions of the United States Supreme Court, and other courts and State Commissions, that no one now raises the question of the propriety of water works rate regulation by the duly constituted bodies to whom this authority is delegated.

The net effect of rate regulation has been to insure invested capital a fair rate of return. While the ratio of privately owned to municipally owned water works properties in the United States has shown a fairly uniform decrease of from approximately 94.5 per cent in 1800, when one publicly owned and 16 privately owned plants were in existence, to about 30 per cent at the present time, when more than 7,000 municipal and 3,000 private plants are estimated to be in operation, this change in ratios of ownership has not been due to unfair treatment of invested private capital by commissions and courts: It is partly due to the fact that private capital has not been attracted to the small municipalities and it has been necessary to finance water works utilities in such places by bond issues, and partly because

[1] Presented before the Missouri Valley Section meeting, October 2, 1928.
[2] Of Black and Veatch, Consulting Engineers, Kansas City, Mo.

other large municipalities, Kansas City, Kansas, and Kansas City, Missouri, for example, have found it desirable to purchase the water utilities constructed by private capital, in order to insure adequate expansion.

Municipal ownership has been popular in the five states comprising the Missouri Valley Section of the American Waterworks Association. Of the estimated total of 926 plants in the territory at the end of 1927, 847 or 91.5 per cent were municipally owned, and 79 or 8.5 per cent were privately owned, with the following distribution by states and ownership.

STATE	OWNERSHIP	
	Municipal	Private
Iowa	176	10
Kansas	280	7
Missouri	140	55
Nebraska	81	2
South Dakota	170	5
Total	847	79

The making or regulating of utility rates is a legislative function, which may be delegated by a state legislature to a board. Inasmuch as the first boards created were for the purpose of handling matters pertaining to transportation, they usually took the name of Railway Commissions. As the scope of their activities were extended, always by legislative authority, some states also changed the names of such boards to Public Service Commissions, or Public Utility Commissions, to indicate more exactly the scope of their power.

The authority to regulate water rates has never been delegated to the Railway Commissions of Iowa, Nebraska or South Dakota, but remains a matter of "Home Rule" for the municipality concerned. The Public Service Commissions of Kansas and Missouri have authority to regulate rates in privately owned water utilities in their respective states, excepting in those cases where water utilities are operating under franchise contracts in effect prior to placing such utilities under Commission jurisdiction, and in special charter cities whose charters specifically reserve the right to regulate their utilities. In general, state commissions have the power to compel utilities to furnish adequate and safe service, at rates reasonable alike

to the utility and the public, and in accomplising this the commission has the power to

1. Grant certificates of convenience and necessity, before admitting a utility to a given field.
2. Go into all phases of utility financing and either approve, reject, or modify the plan.
3. Establish rates.
4. Control service.
5. Establish uniform accounting systems, and
6. Determine whether or not a utility should be allowed to discontinue service.

These items merely serve as an indication of the broad powers conferred on commissions generally. There are incidental details too numerous to mention, but necessary in the regulation of utilities, and of importance both to the utility and the public. Without doubt both utilities and municipalities in those states having commissions to which rate matters at issue may be referred, are in a position to get a fuller and more comprehensive analysis of the issues than otherwise.

Court decisions affecting rate matters were either made in advance of authority in such cases being delegated to commissions, or are made as result of appeal from the decision of commissions on the theory of lack of jurisdiction. Commissions are a part of the legislative branch of the government, national or state, as the case may be, and cannot usurp the authority of the courts, constituting the judicial branch. To explain the difference between the powers of these branches of the government, the Missouri Supreme Court in the case of Missouri Valley Realty Company versus Cupples Station Light, Heat and Power Co., quoted from Prentis v. Atlantic Coast Line Company as follows:

> A judicial inquiry investigates, declares, and enforces liabilities as they stand on present or past facts, and under laws supposed already to exist. That is its purpose and end. Legislation, on the other hand, looks to the future and changes existing conditions by making a new rule to be applied thereafter to all or some part of those subject to its power.

And in its decision continues to say:

> While there are many refined distinctions which may arise in distinguishing between the legislative and judicial powers, the foregoing distinction, although general, is accurate and they must all measure up to its terms; and in so far as the Public Service Commission makes rules and orders within its legislative authority with reference to those matters and duties with which it is charged

by legislative enactment, those rules and orders become by virtue of its delegated legislative authority, the law of the land, and rates and duties accruing under them are to be enforced accordingly. . . . . Its powers and duties are broad and comprehensive; they include the protection of the people of the state against extortion and inconvenience arising from neglect and misconduct in the service of the Public Utilities which have been placed under its supervision and control. . . . . In all these things it acts by virtue of the legislative authority with which it is clothed and necessarily within the limits of the legislative power. . . . . When the existence, validity, force, or effect of a law is called in question in a contest between individuals or corporations, a judicial question is involved which is not within its authority to determine, because the same function was not within the authority of the legislature.

Appeal to the courts from commission decisions is ordinarily on the theory of confiscation, the taking of property without due process of law, which is a violation of the fourteenth amendment of the constitution of the United States; a rate which does not give a "reasonable" return on the property used and useful in the public service is considered confiscatory by the courts, and to the extent of correcting such a rate, the findings of commissions are overruled.

The rate to which any operating water works property is entitled is one returning sufficient revenue to pay all operating expense, provide a reasonable return on the fair value of the property used and useful in the service, and maintain the property so it may be returned to the owner at the end of his contract in approximately the same physical conditions as when first put in service. This principle is so well established by commission and court decisions that further discussion is unnecessary. In the case of municipally owned and operated plants, there is no question but the rate of return should be sufficient to provide also for ordinary extensions of the property without the necessity of trusting to the sometimes doubtful authorization of the proposed expenditure by bond elections. The Kansas Emergency Law, whereby a municipality may issue bonds for water supply improvements, under authority of the Public Service Commission, and without the vote or consent of the taxpayers, is evidence of the fact that the matter of water supply may be so urgent that the municipal authorities are justified in avoiding delay and the risk of the failure of a bond election. And it may be said at the same time that Kansas municipalities seldom refuse to vote bonds for important and necessary public utility improvements.

In some states the law makes the use of operating revenue for constructing extensions illegal excepting upon specific showing by the

city authorities that emergencies exist and it is necessary to use the operating surplus for the purpose of extensions rather than undergo the delay, and uncertain outcome, of voting bonds. There is no valid objection to the use of surplus revenue for this purpose, provided the rates in effect equitably distribute the rate burden, particularly for fire protection, between vacant and non-water using property, and the water users.

Extensions of privately owned water works systems are made of necessity by investment of additional capital in the enterprise, and cannot properly be made from surplus returns over and above the return necessary to pay all operating expense, provide a reasonable return on the fair value of the property used and useful in the service, and maintain the property so it may be returned to the owner at the end of his contract in approximately the same physical condition as when first put in service.

The allowance for operating expenses in a rate controversy is controlled largely by the experience of the operating company as reflected by its books, corrected of course for errors in classifying charges to operation. The fact that an operating company has not operated efficiently or wisely is seldom given such weight by a court or commission that it results in penalizing this item; the management of a utility is supposed to be a better judge of the necessity of incurring certain questionable times of operating expense than either the valuation engineer or the courts. However, in rate cases commissions ordinarily are quick to comment on the matter of efficient operation of a property, and to indicate that in fixing the final rate of return, a higher rate was allowed than would be allowed an inefficiently operated property. Commission rulings indicate specific increases in the rate of return expressed in per cent, of from 0.5 to 1 per cent, for efficient operation as against inefficient operation. In certain states in which standards for gas leakage have been well determined, gas utilities applying for rate adjustments are penalized for excess loss by increasing the operating revenue by the cost of excess gas lost. Inefficient operation of water works utilities does not lend itself to such direct treatment.

FAIR VALUE

The fair value of the property used and useful in the service is difficult to determine. A property is made up of many items and its value is susceptible to wide variations, depending on the theory on

which it is valued. Engineers on opposite sides of a rate hearing may take the same items of property and arrive at widely varying results, by use of the same methods. Sometimes these differences result from ignorance of real construction costs, or the misapplication of costs on one project to the property in question. A commission or court therefore must exercise rare judgment in placing its faith in the creditability of one expert as against another, or in discounting the testimony of both, and arriving at a valuation of its own on some basis unnecessary to detail in handing down a decision.

Courts and commissions in fixing the fair value of a property ordinarily consider its cost of reproduction new, its cost of reproduction new less depreciation, its "book" or historical value, or combination of the three, in arriving at the rate base. The cost of reproduction new value, considers the property replaced at today's current prices, if such prices are fairly stable and representative of prices which will probably prevail for some time. Otherwise prices at which the property may actually be replaced must be used. The book or historical value of a property is made up from the investment records of that property, adjusted where necessary to account for items improperly charged to capital account.

The unit prices applied to units of property should be determined only after careful and intelligent investigation of construction actually experienced by the utility, adjusted to meet conditions as at the date of the appraisal and particularly revised to eliminate the over exaggerated burden of piece-meal construction. Piece-meal construction as practiced in later day extensions to a utility built originally as one unit, has no place in finding the fair value of a property, because it is frequently made up of many construction projects totaling to large amounts, but representing individual job expenditures of less than $100.00. The "reproduction new at present prices" theory cannot fail to be influenced by present conditions of construction as well as by the necessity of reasonable piece-meal costruction, of which the construction experience of the average utility is not a fair measure.

Unit prices developed for application to units of property may or may not include all of the direct charges to construction, such as omissions and contingencies, stores expense, workmen's compensation, public liability, tool expense, performance bond and contractors profit, and if they do not include these and other direct construction costs, it is necessary to include them later under general

construction overheads, which are usually held to include in the valuation of all privately owned plants,

(*a*) Preliminary organization of project
(*b*) Engineering
(*c*) General administrative overheads
(*d*) Interest during construction
(*e*) Going value
(*f*) Working capital
(*g*) Materials and supplies

The extent to which these, and possibly other items of similar nature, enter into a rate base, depends entirely on the particular property under consideration, and the decision as to the amount to be added to the "bare bones of the plant," or its cost of construction, varies from 10 to 25 per cent of its cost of reproduction.

Time does not permit discussion of each of these items, but it is of interest to note at this point that cases in three states represented here laid down far reaching decisions in utility rate cases. The Des Moines Gas case established the precedent that, in determining the reproduction cost of a property, paving over mains should not be included as an item of value excepting where it had been cut for the laying of mains. This theory is now universally applied by engineers in rate cases. In the Omaha vs. Omaha Water Company case, the Supreme Court of the United States held that in a valuation for municipal acquisition of water works property, a specific allowance for going value was proper, but nothing might be included for good-will or franchise value. Franchise value is allowed by commisssions in some states at the actual cost of securing a franchise. Oridinarily this is determined by the cost of the holding of special elections. In the case of the purchase of the National Water Works Company by Kansas City, Mo., Chief Justice Brewer laid the ground work for the inclusion of going value in succeeding cases by saying in effect that it was obvious that the mere cost of purchasing the company's land, constructing buildings, putting in machinery, and laying the pipes in the streets, in other words the cost of reproduction, did not give the present value of the property, that a completed water works system without a single connection between the pipes in the streets and the buildings in the city would be a property of much less value than that system connected with so many buildings and earning in consequence thereof the money which it does earn, that the fact that it was a system in operation not only with a capacity to supply the city, but

actually supplying many buildings in the city not only with the capacity to earn but actually earning, made it true that the fair and equitable value was something in excess of the cost of reproduction.

"Going value," in short, is ordinarily defined as the difference in value between two identically similar plants, one complete and ready to do business, but with no customers attached and the other enjoying a profitable business. Courts and commissions are at variance on the universal admission of this item as a part of the rate base in rate cases and its inclusion has been denied in many cases. However, the preponderance of decisions are for its inclusion. The method by which the amount allowed shall be calculated has not been defined by court decisions, but allowances have been made as low as 3 and as high as 20 per cent of the total cost of reproduction. Commissions are apparently inclining more generally to the theory that going value must be proved and that the testimony of experts must be based on definite grounds rather than on alleged expert opinion. Opinions indicate that the amount of going value is measured by the cost of developing the business, and as such should be reflected by the books of utility. There are court decisions to the effect that in valuing an operating property the appraiser includes going value in the make-up of his unit prices, as opposed to valuing a non-operating property in which his findings would reflect "junk" prices. It is the author's opinion that no single item of intangible property is deserving of such prayerful consideration as this one.

DEPRECIATION

To determine the cost of reproduction less depreciation, it is necessary of course to fix the total accrued depreciation of the property. Depreciation is of two kinds, physical and functional; physical depreciation is the wasting away of property due to use, wear and tear, exposure to the elements, or from any other causes which eventually render it useless for performing its service. Functional depreciation may be defined as loss of value due to development of materials or equipment performing the functions originally performed, more economically or efficiently.

The determination of the amount of depreciation is a difficult matter, and the straight line, the sinking fund, and the inspection methods have been variously employed and supported by decisions. Courts apparently lean toward the inspection method, as being more accurate than theoretical methods involving the use of life tables.

Obviously, the inspection method does not entirely eliminate theory nor life tables, and it has little value when appplied to a one hundred per cent hidden property, like a water distribution system, and no method has any value when applied by one unacquainted with the physical and accounting history of the property, whether he be an expert or not. Court and commission decisions are practically a unit in deducting accrued depreciation from the cost of reproduction of the property in determining the physical property measure of a rate base.

The rate of return allowed to provide for depreciation of a water system is not subject to the same degree of variation as that of other shorter lived utilities. While the management of most utilities have proceeded in times past on the theory it was necessary to accumulate a depreciation reserve at the rate of from one to two per cent annually for meeting depreciation, and to pay maintenance and repair expense as items of ordinary operation, water utilities are by no means a unit in support of this theory. The Detroit Water Board has recently determined as a matter of business policy to make all charges for maintenance, repairs and depreciation, to operating expense, rather than to continue the accumulation of a depreciation reserve. In the management of privately owned and operated utilities there is much room for argument between the regulatory commisssions and the utility as to the proper distribution of depreciation, maintenance and repair items between the depreciation reserve and operating expense; charges to operating expense rather than to the depreciation reserve, creates a large reserve not subject to the jurisdiction of courts and commissions.

FAIR RETURN

The fair and reasonable return on the fair value of a water utility over and above operating expense, depreciation and taxes, is perhaps more definitely settled by court decisions than in the case of other utilities, such as gas and electric properties, and 7 per cent is perhaps a fair average. With operating expense, depreciation and taxes, and the reasonable rate of return determined for a given property, the gross income may be projected on the sales experience of the utility, and the problem of adjusting the rate to various consumers started.

FIRE PROTECTION CHARGES

Probably the most difficult problem water utilities have is the apportionment of the fire protection burden between water users and

non-water-using property. The investment in fire protection varies from 25 per cent of the total investment in large utilities to 70 per cent in small utilities, and as much as 50 per cent of the total operating costs may be due to fire protection. Various methods are employed for determining the proportion of the fire protection costs which should be charged to the municipality at large and to the water user. While utilities in some states have made decided progress in equalizing this burden, the average sized municipally owned utility in this section has not yet properly equalized this burden. Attempts in the right direction are being made, and Kansas, for example, levies against all property within the city for fire protection, as follows:

Cities of first class

40,000 or less population—3½ mills for water, light, heat and power. Statutes 1923, Ch. 79, 1923.

40,000–60,000 population—1 mill for hydrant rental. Statutes 1925, Ch. 281.

60,000–80,000 population—1 mill for all water. Statutes 1923, Ch. 79, 1926.

Above 80,000 population—4 mills for all water. Statutes 1923, Ch. 13, 902.

Cities of second class

Above 10,000 population—5 mills for hydrant rental. No tax can be levied if plant is municipally owned. Statutes 1923, Ch. 14, 1005.

All other cities of 2nd class—1 mill for hydrant rental. Statutes 1925, Ch. 283.

Cities of third class

1 Mill for hydrant rental. Statutes 1925, Ch. 283.

MUNICIPALLY OWNED UTILITIES

Most of the court and commission decisions respecting water rates have had to do with privately owned water utilities, because few states have undertaken the regulation of municipally owned water plants. However, municipally owned plants must meet all the expense items ordinarily incurred by the privately owned plant, with the possible exception of taxes, and are under the necessity of earning interest and sinking fund reserves during the life of the bonds. The object of municipal ownership is to sell service at as near cost as possible, and to sell it at a lower rate than the privately owned plant can sell it, if possible. It is a mistaken idea, however, that the service from a municipal plant should be sold for less than cost, for some day

the reckoning will have to come and when it does the chances are it will be due to the failure of establishing a rate on a base taking into consideration all the contingencies of plant operation and financing. The struggle for existence of some of the smaller municipally owned water systems, is due, almost without exception, to lack of consideration of the fundamentals in fixing a rate base. No water utility can go on indefinitely receiving less than cost for service rendered. Few water systems are able to start on a less than cost basis and later raise rates to cover deficiencies. Some systems may continue to operate for a few years by covering operating deficiencies by taxes, but sooner or later the public will insist, and rightfully, on a just and scientific adjustment of rates, or on private ownership.

In my opinion any well governed city is capable of giving service from an intelligently designed and operated water works system at a lower cost than the same service can be given by private ownership. This statement is not a reflection on the city government, or the design and operation of any municipally owned plant which may be running behind financially. However, it may be cause for the officials of such cities and towns to consider carefully the question as to whether or not competent design, supervision and operation are being obtained, whether water departments are being hampered by politics and the selection of operators totally unfit for such work. Intelligent supervision of finances and operation is not confined to operating heads of private companies rather than to the business men making up the average governing body of our municipalities. Competent water works engineering and operation are not solely functions of private water companies.

In 1927 the Wisconsin Railway Commission, which has jurisdiction over all water utilities, both privately and municipally owned, in Wisconsin, handed down a decision in the Milwaukee water case upholding the city's right to treat this city owned utility on exactly the same basis as a privately owned utility for the purpose of fixing rates. In arriving at the rate base the Commission wrote off property not used and useful, allowed taxes, and 8 per cent return on the investment. It considered without giving any light on its disposition in the matter, a going value item of $2,500,000 claimed by the city, and allowed the city's proposed rate of 7 cents per 1,000 gallons of water for all consumers, regardless of quantity used.

There is no reason why municipally owned plants should not proceed on the established theories for fixing rate bases, and determining

and collecting a reasonable rate of return on property used and useful in the service. Conditions change from time to time and rates require revising. In California this fact is considered of such importance that the Utility Commission in that state has the authority to review each year every rate of every public utility operating in the state. Yearly readjustment of rates may not be necessary or desirable, but it is essential that when rates are made they provide for all the proper elements of a rate base, and a proper distribution of rate burden in order to protect the utility, the user, and the property owner.

ADVANTAGES AND ECONOMIES OF A COMBINED WATER AND POWER PLANT[1]

By J. D. Donovan[2]

In discussing the advantages and economies of a combined water and power plant, my conclusions are based primarily on the combined operation of the Kansas City, Kansas, water and electric plant. It is not my intention to leave the impression that combined operation of such plants is always advantageous to both, because there are naturally some disadvantages, particularly to the water plant, which in my opinion, however, are more than outweighed by the many advantages.

Discussing the advantages somewhat categorically, the first item to be considered is that of investment and the first item of investment is that of intake and low pressure pumping facilities. We have at our station an intake well located within the harbor lines of the Missouri River having a maximum capacity of approximately 100,000,000 gallons daily. This well is fitted with revolving trash screens and serves the purpose of supplying water to the settling basins as well as to surface condensers on turbo-generating units. Adjacent to the intake well is a low pressure pumping station having a total pumping capacity in motor-driven centrifugal units of some 90,000,000 gallons per day. Both of these investments are jointly used by the water and electric plant and, except for the capacity of installed pumping equipment, would amount to substantially the same investment were either plant to be operated separately so that some saving in fixed charges to both plants is effected through this means.

From the pumping station to the settling basins there are two discharge mains that pass first through the turbo-generating room and then to the settling basins. They are so valved and inter-connected that either main can be used on any particular turbo unit with the final discharge of water being made in the settling basins. This

[1] Presented before the Missouri Valley Section meeting, October 3, 1928.

[2] Chief Engineer, Water and Light Department, Kansas City, Kans.

flexibility of piping arrangement would, of course, be unnecessary were water delivered from the low service station to the settling basins for water service only, but inasmuch as the investment necessary for this flexibility is provided primarily by the electric plant, it does not in any way affect the ultimate investment of the water plant. It is true, of course, that some additional head is encountered in pumping water through the more circuitous route required to serve the light plant and a further additional head of approximately ten feet is encountered through the friction of the surface condensers, but this difference in pumping head is absorbed by the light plant in the pro-rating of pumping cost and hence does not affect any increase to the water plant.

This arrangement would, of course, have limitations based primarily on the balance of requirements for water as between the electric plant and the water plant; that is to say, up to a point where the load requirements of the two plants are equal the maximum of economy is obtained. After this point is reached and the requirements for circulating water for surface condensers commences to equal the requirements of the water plant for water, the advantages commence of course to disappear and would eventually be lost altogether when the difference in water requirements of the two plants becomes great enough, because, if you must supply, say, twice as much water for electric service as is required for water service and the total quantities must be pumped at the full head required for water service, the advantages of this feature of combined operation disappear entirely. In the Kansas City station this point has been reached and it will be necessary within the course of the next year or so to separate at least a portion of the pumping load so as to lower the head requirements of the excessive quantities required for electric purposes.

In the design of condenser equipment at our light plant, we are required to specify a maximum water temperature existing in the Missouri River during the summer period of 80°F. Under these conditions it is necessary that we specify approximately two square feet of condenser surface for each kilowatt of turbo-generator rating and with this temperature of circulating water, we require approximately 0.9 gallon per minute per square foot of condenser surface or 1.8 gallons per minute per kilowatt of turbo-generator capacity. At the present time our normal peak load is slightly in excess of 16,000 kilowatts requiring circulating water at the rate of slightly more

than 28,000 gallons per minute. The load factor, however, on the electric plant is such that the average requirement for condenser water represents only 56 per cent of this amount or approximately 16,000 gallons per minute, which average amount represents the approximate present requirement of the water plant.

This means that during times of heavy load on the electric plant we are now forced to waste a certain per cent of our circulating water not required by the water plant. This waste of course is of water at a head much higher than would be required for the electric plant only, hence this advantage of combined operation is commencing to decline because of the more rapid growth of the electric plant than that of the water plant. In order to maintain a reasonable degree of economy through this combined operation it will be necessary in the near future to isolate certain generating capacities and provide two different pressure heads on our low service system.

The passing of this low pressure water through surface condensers gives an advantage to the water plant during the winter season of the year due to the fact that the temperature of the water is increased enough to prevent the formation of ice on the settling basins, as well as aiding materially in the chemical reaction of applied chemicals, but of course it reacts in the warmer periods of the year to a disadvantage due to raising the temperature of the distributed water to a point considerably in excess of the natural river temperature, the ordinary rise over the condensers being between 10° and 15°F.

The high pressure pumping equipment at the Kansas City plant consists of two 12½ m.g.d. cross compound, condensing crank and flywheel type pumping engines and one 25 m.g.d. two-stage, synchronous motor-driven centrifugal pump and in the pumping of high pressure water by these units we again have the advantage of joint investments. This division of the water plant is operated strictly on a customer basis, that is, the water plant is a customer of the electric plant and the electric plant furnishes to the water plant either steam for the operation of high pressure steam pumping equipment or electric energy for the operation of high pressure water pumping equipment.

There are, however, certain investments held jointly by the two departments and these are taken into consideration when fixing the rates charged for either steam or electricity to the water department. The boiler plant building, for instance, houses equipment owned jointly by the two departments by far the larger portion of which

belongs to the electric plant and this of course is served by a common set of coal and ash handling equipment. Likewise, the main engine room houses high pressure pumping equipment as well as turbo-generating equipment and is served jointly by the same crane and other common facilities. It is evident that, if either plant were operated separately, they would be required to support individually these points of common investment. This would naturally reflect some increase in their operating expenses.

In the Kansas City plant it is our plan to operate the 25 m.g. motor-driven unit as much of the time as possible and it might be interesting to know that in the seven years this pump has been in service it has furnished the city's water supply continuously for all except slightly over seven days of this time. Our reason for operating this unit continuously of course would not be parallel to what may be found in other pumping stations, but to us it means an enormous saving in operating expense through the saving of packing, pump valves, lubricating oils and other miscellaneous supplies needed in the operation of crank and flywheel type of pumping units. It is no doubt true that present development in turbine-driven centrifugal pumping units would not offer, by any means, the same comparisons of economy as prevails in our station. On the other hand, where the size of the prime movers in the electric plant are sufficiently large to permit design having low steam consumption per kilowatt hour, the ultimate duty obtained from a motor-driven unit is substantially the same as can be obtained from a steam turbine driven unit of the same size and under the same steam conditions.

The motor used on our centrifugal pump has been especially designed for power factor correction and it is this feature in its continuous operation with our light plant that enables us to furnish electric energy to the water plant at a low rate, because the electric plant benefits very materially through this in power factor correction on the station bus bars. We are, of course, enabled to operate in this manner without violating any requirements of the National Board of Fire Underwriters because the boiler plant is always under pressure serving the steam requirements of the electric plant. Should electrical outage occur, the steam pumping equipment is ready to move on a moment's notice from steam supplied through the same source, hence continuous operation of the electric water equipment is not burdened with any standby boiler expense, the only cost to the water department when operating with steam being that which they are charged

on a per thousand pounds basis for the time which it is used. The electric plant profits materially through this continuous operation of electric water equipment to the extent that excitation losses on the turbine units are reduced to a minimum and machine capacity is maintained at a maximum with decidedly improved regulation. In fact, were it not for this particular motor in our plant today, we might on account of our heavy industrial load (which of course is for the most part inductive) have to furnish separate condenser equipment in order to be able to develop full electric capacity from our generating units at all times.

The next point of advantage in the combined operation of water and electric plants would apply generally to all combined installation and that is the matter of superintendence, operation and maintenance of the equipment of both plants. In our plant we have, for instance, one chief engineer who has complete supervision over both plants and we have but one operating engineer on each shift who in turn supervises the operation of both plants. In the routine operating crews there are, of course, certain individuals who would not be dispensed with were the plants separated; that is, their total time at work is occupied in the interests of one or the other department, entirely but in the maintenance crews the advantage of joint operation is again reflected in the fact that the same mechanics repair and maintain equipment of both departments. While it is true that the combined operation requires somewhat more in the number of men employed, it is also true that were the plants to be separated, it would not be possible to diminish the crews by one-half. It is my personal experience that joint maintenance reflects very substantial savings to both plants in their regular routine operation.

In the distribution of water and electricity it is not possible to effect any great economies through combined operation due to the wide diversity in the character of the work performed in this particular function. It becomes almost necessary to maintain separate organizations for the water and electric plant.

There is, however, considerable advantage in the operation and maintenance of a common warehouse and storeyard at which point materials are received and disbursed for the use of either the water plant or the electric plant distribution system. Our storeyard is supervised and operated by a single crew and were the two departments to be separated, it is doubtful if we could dispense with over one-third of the help because so much of the work involved is routine

and the excess is only measurable in the increased quantities of materials to be handled through joint operation.

When we reach the service and billing departments we again are able to take advantage of joint operation in a great number of ways. For instance, our meter readers read both water and light meters. While it may take somewhat longer to read two meters on the premises of one customer, it certainly does not take twice as long and consequently some substantial saving is made in this respect. Following this through with the service department and trouble men substantial further economies are effected.

I should like to present to you some definite figures on just what it means to the City of Kansas City, Kansas, to operate its electric and water plants jointly and just what saving is effected in dollars and cents. To do so involves, however, so many points of estimate that I do not feel the figures would have any particular value. We have at various times been confronted with a possibility of the separation of the two plants through the possible sale of the electric plant. In order to answer intelligently some of these arguments we have prepared estimates showing how production cost in the water plant would be affected were the light plant to be disposed of. The result of these investigations and estimates has indicated that the water plant would require approximately 40 per cent more gross income were it to be operated separately, which indicates the folly of attempting to dispose of the electric plant and which also I believe proves conclusively that there are great economic advantages to be gained through the joint operation of electric and water plants where there are no limiting physical conditions other than what prevail in Kansas City.

GROUND WATER SUBSTITUTED FOR FILTERED WATER[1]

By E. T. Archer[2]

It is the intention of this paper to discuss the feasibility of substituting ground water supplies for filtered water supplies in cities requiring a large volume of water. As an example of the application of this theory the city of Shawnee, Oklahoma, where a similar improvement has just been completed, has been selected.

Shawnee is a city of about 25,000 inhabitants located 30 miles east of Oklahoma City, on the North Fork of the Canadian River from which it has been drawing its supply of about 2,000,000 gallons of water per day.

As a source of supply the North Fork of the Canadian River has much to be desired. Originating in the northeast corner of the state of New Mexico, it flows in a southeasterly direction, eventually uniting with the Arkansas River near the Arkansas and Oklahoma line. During its course it flows through the salt plains of northwestern Oklahoma and various oil fields along its course where it accumulates the oil field drainage as well as the sewage of various towns along its banks. It is a much polluted stream.

Practically all the towns along its course have abandoned it as their source of water supply except Oklahoma City where its use is continued only by the city having made arrangements to impound the flood flow and by-pass the dry weather flow and by treating the supply in one of the most elaborate and modern filter plants in the middle west.

Since the flood flow constituting the best of the water is impounded and the sewage from Oklahoma City, until recently untreated, and now receiving only about a thirty minutes' settlement, is discharged into the dry weather flow, it is not surprising that the water becomes somewhat contaminated. To add to the difficulty this condition has resulted in an almost ineradicable growth of algae along the stream causing an odor which cannot be entirely removed by aeration and treatment.

[1] Presented before the San Francisco Convention, June 13, 1924.

[2] Consulting Engineer, Kansas City, Mo.

The chemical treatment given the water in the purification process consisted of 6.2 grains per gallon of alum and about $3\frac{1}{4}$ grains of lime per gallon. The water as finally delivered to the city contained about 735 p.p.m. of solids, as well as some odor.

The city's original water system was built in 1904 and at that time no treatment whatever was provided. In 1914 a small filter plant with a capacity of about 1,000,000 gallons per day was built and in 1920 there was built, from the proceeds of a $200,000 bond issue, a modern filter plant with a capacity of about 3,000,000 gallons per day.

The filtration plant, in general, consists of a 3,000,000 gallon concrete roughing basin, 750,000 gallon concrete sedimentation basin, rapid sand filters, aeration equipment and a clear water storage of about 200,000 gallons. The total invested in the filter plant, including the several bond issues is approximately $300,000. The population of Shawnee had grown from 6,000 in 1900 to 18,000 in 1926. With the development of the Seminole oil fields, about 30 miles east of the city, the increase in population has been very rapid until at the present time the city has a population of about 25,000 people.

Due not so much to the hardness of the water, but to its color, odor, and the well disseminated idea that Shawnee was drinking Oklahoma City sewage, the local sentiment had grown much opposed to the continuance of the river as a water supply. In order to ascertain if it were possible to better their water supply condition our firm was employed to make an investigation and report on a new source of supply and, if found feasible, to prepare plans and specifications for the same, the idea being to secure a well water supply if possible and to get away entirely from the use of surface water.

NEW WATER SUPPLY REQUIREMENTS

The requirements governing a new supply were summarized as follows: Permanent daily supply of 3,000,000 gallons, reasonably soft water of good quality; an initial installation cost within the economic reach of the city and an efficient operating installation.

It was obvious that to secure a ground water supply, complying with these demands, the engineering studies would have to cover a considerable scope.

Inasmuch as there were no large wells in or around the vicinity of Shawnee that would indicate the presence of any pronounced water

bearing strata, a study of the general topography of that part of the state was begun with the idea of narrowing the investigation down to a more local area.

From the geography of the state it was noted that the city lay between the Cimarron River about 45 miles to the north and the Canadian River about 25 miles to the south. Intermediate between these rivers are the Deep Fork branch of the Canadian River 20 miles to the north and the North Fork branch of the Canadian River at the south edge of the city. These rivers all flow in a southwesterly direction with the dip of the ground.

The North Fork of the Canadian turns north at the east limits of the city for a distance of about 12 miles, thence southwest again, forming an area to the west bounded on the north by the Deep Fork River and on the south and east by the North Fork of the Canadian, this area having an approximate extent of 20 miles in width and 30 miles in length.

The geology of this section of the state gave no evidence of underground water bearing strata between the two water courses but did show the presence of a considerable sand area throughout the section under consideration.

Surface conditions also indicated that the territory northwest of the city was of a sandy nature and on the southwest rocky and cut up. It was, therefore, deemed advisable to make a more detailed investigation northwest of the city.

In carrying out this idea an investigation was made of the more prominent domestic water wells throughout this section. In this work we were ably assisted by Mr. Bean, a member of the City Council who had for the past thirty years specialized in water well construction throughout this section of the state. From information from him and other drillers, supplemented by local investigations, a knowledge of the water wells throughout the section was secured from which it was found that a sand and gravel water bearing stratum varying in depth extended from the north limits of the city a distance of about 20 miles northwest, varying in width from $\frac{1}{4}$ mile to approximately 4 miles. In this area an abundance of good water had been secured from rather shallow domestic wells. On the basis of this information it was recommended that tests be conducted throughout this area.

DATA FROM TEST WELLS

In the test work some 150 holes were drilled aggregating a total of about 9,000 linear feet. A small portable test rig with a rotary bit attached to the rear of a Ford truck was used in this work. The results when plotted showed that the sand stratum extended over an area of from ½ to 4 miles in width for a distance of about 22 miles to the northwest, the depth of the stratum varying from about 2 feet at the edge to about 23 feet in the center, with an overburden of from 5 to 20 feet of earth.

It was apparent that the entire area constituted somewhat of an underground connection between the Deep Fork River lying about 20 miles to the north and the North Fork of the Canadian River immediately to the south and that the water in this area was supplied from surface percolation throughout the district and the underground connection with the Deep Fork River.

The sand from the test holes was coarse and clean and contained a considerable percentage of well rounded gravel indicating that little difficulty would be experienced in securing the required quantity.

The study of the test data with respect to the location of the best part of the water bearing strata disclosed that the coarsest portion of the sand area and the maximum depth lay in an area of about 80 acres situated about 2¾ miles northwest of the City Limits.

From these data and the drilling of additional test holes at the proposed site of each well, locations were made for 12 wells, fairly well distributed over the 80 acre tract.

The investigation and tests were carried forward on the assumption that the entire supply of 3,000,000 gallons per day could be secured from a reasonable number of wells, necessitating an individual capacity of each well of 175 to 200 gallons per minute, which requires a vastly different type of well than the ordinary farm wells prevailing throughout the section.

The possibility of securing such a large volume of water from sand strata is not without precedent as such results have been accomplished and made possible by the advent of the gravel wall type of well wherein double casings are used and the finer sand is baled out and replaced with graded gravel.

The chief advocates and developers of this type of well have been the Layne-Bowler Co., of Memphis, Tennessee. Other companies like the Kelly Well Co., of Grand Island, Nebraska, the Air Made Well Co., of Kansas City, Mo., and different concerns have more

recently developed wells along similar lines and have patents covering their screens and methods of gravel application, etc.

The results secured, however, are not always the same for the different companies have developed different methods of construction, use different strainers and different sizes of gravel, each specializing in some particular conditions in which their methods have produced the greatest results. It is, therefore, necessary that the engineer be familiar with these different methods and use discretion in choosing the type of well that is best fitted for the particular conditions from which he expects to secure the supply, as the success of the installation depends largely upon the construction of the well.

CHOICE OF PUMP

Coincident with the development in well construction there has also been developed a type of pumping equipment for use in connection therewith.

The older types of well pumps, consisting of the reciprocating deep well types with cylinders at the water level, were capable of pumping only a limited quantity of water and were subject to considerable trouble and upkeep expense where sand was carried in the water.

Among the more recently developed types are the vertical centrifugal pumps which are capable of handling very much larger quantities of water and small percentages of sand without serious detriment.

The old time air lift pumping system, which is capable of handling large percentages of fine sand, has in late years been revived and somewhat improved in both efficiency and operation. It is particularly fitted for conditions where it is advantageous to backblow the strata and loosen the fine sand which can be taken out without injury to the pumping equipment.

The efficiency of the air lift equipment, however, is a maximum of only about 35 per cent compared to a maximum of centrifugal pumps of 75 and of reciprocating pumps of 80 per cent and is therefore not adaptable except where fine sand is encountered.

The condition of the water bearing strata, type of well, etc., determine definitely the type of pumping equipment to be used for the particular development. Where very fine sand is present and the strata contain only a small percentage of gravel or coarse sand it is obviously an air lift proposition. Where the fine sand, passing a

50 mesh, does not exceed 25 per cent of the stratum the centrifugal pump is particularly adapted. When no sand is carried in the water and the pumping level is exceedingly deep and the capacity required is small the reciprocating pump is still applicable.

The efficiency of the particular type of pumping equipment, however, does not always determine the choice. Obviously it is the engineer's province to choose the most economical equipment possible, but when the word "economy" is applied in its broadest sense to a well development it sometimes includes considerations other than power consumption. Rapid deterioration of the equipment and general upkeep cost with higher initial coefficiency as compared with longer life and longer sustained average efficiency usually determine quite definitely when correctly diagnosed, the type of equipment most adaptaple.

Therefore, in determining the particular type of equipment most suited to the condition at Shawnee the continuous overall efficiency was the controlling factor.

A study of the stratum indicated that with a properly constructed gravel wall well a centrifugal pump installation was best adapted. Therefore, after a considerable study of the different types of deep well centrifugal pumps available, it was decided to install Layne-Bowler pumps that had been developed for these particular conditions.

From tests it was found that the wells gave a continuous supply ranging from 175 to 200 gallons per minute, the variations resulting from the depth and coarseness of gravel of the stratum at different locations.

One point which was observed particularly in determining upon the size of pumps was the draw-down in the well. In no case was the draw-down allowed to go below 50 per cent of the water bearing stratum. This rule in general if carried out would save a large number of installations that have been ruined by over-production. In order to facilitate increased production and to allow for any restriction in the capacity of the wells two additionl wells were constructed, capped and held in reserve for the future.

NEW WELL SYSTEM

As ultimately designed the well supply consists of 12 gravel wall type wells with 30-inch diameter outside casing and 15-inch diameter inside casing with the area between the two casings filled with graded gravel.

In the construction of these wells the outer casing is gradually withdrawn to a position above the water bearing stratum as the gravel is placed, thereby resulting in a large gravel deposit around the screen acting as a supplementary screen and increasing the voids in the material and allowing the water to flow at a slower velocity carrying less of the fine sand into the well.

The wells range in depth from 39½ to 47 feet and the average log of the 12 wells is as follows:

Clay	First 17 feet
Fine sand and clay	Next 5 feet
Fine sand	Next 6 feet
Coarse sand and gravel	Next 16 feet
Total depth	Next 44 feet
Average water level	21 feet

The water bearing stratum proper, consisting of coarse sand and gravel, ranges from 12 to 23 feet in depth, averaging 16 feet for the 12 wells. This is the stratum from which the water supply is secured, although the 5 feet above this are below the water level but are cased out by the outside casing.

Each well is equipped with an individual deep well centrifugal pump and motor and is connected to a 4-inch discharge line, which in turn connects with a 12-inch line emptying into a 1,000,000 gallon reinforced concrete collection reservoir.

The results of the development have justified our hopes, as the wells have produced 3,500,000 gallons per day continuously with no material interference.

RECONSTRUCTION OF DISTRIBUTION SYSTEM

Due to the fact that the new supply is almost in the opposite direction from the original source, considerable difficulty was anticipated in adapting the old distributing system to the most economical use of the new supply, particularly with reference to fire service. It was originally intended to flow the water by gravity from the 1,000,000 gallon collecting reservoir at the wells to the roughing basins at the filter plant, a distance of about 5 miles, from which it was to be pumped through the old pressure lines to the city.

More mature consideration, however, disclosed the fallacy of this plan and with the coöperation of the underwriters it was shown to the city that better fire protection and more efficient operation could be secured, as well as considerable saving made in the first

cost, were the original plant abandoned or rather kept as a stand-by unit and an entirely new pressure line and pumping plant constructed from the new supply direct to the city.

Following out this idea a new pumping plant was designed near the site of the new reservoir. This plant consists of duplicate 4,000,000 gallon high pressure pumps of the horizontal centrifugal, motor driven type, manufactured by the American Well Works Company. These pumps deliver the water through $2\frac{3}{4}$ miles of 20 inch high pressure line direct to the new 500,000 gallon water tower located in the residence section of the city, from which the water is conducted to the heart of the original distributing system by a 14 inch line and a number of 6- and 8-inch cross connecting lines, converting the old 3,000,000 gallon roughing basin into a storage reservoir for emergencies, thus precluding the necessity of ever pumping river water in case excess demands were made upon the supply.

The old 100,000 gallon water tower was left in service by means of an altitude valve, sufficient funds being provided for repainting and roofing of the structure.

By this design the City of Shawnee is given two separate and distinct sources of supply, which in an emergency can produce 8,000,000 gallons of water in twenty-four hours, by mixture of the ground and river waters, or can produce 3,000,000 gallons of ground water per day indefinitely with an additional 3,000,000 gallons held as an emergency reserve for fire protection, Inasmuch as the present demands are about 2,000,000 gallons per day, this should be entirely adequate and can be increased from time to time by adding additional wells as the pumping station and pipe lines are good for a total of about 8,000,000 gallons per day.

The total cost of the water supply proper, consisting of the wells, collecting reservoir, high pressure pumping plant and the $2\frac{3}{4}$ miles of 20-inch pressure line to the city amounts to \$191,000. The remainder of the bond issue of \$586,000 was expended on improvements within the city, consisting of 26 miles of distributing lines, the 500,000 gallon water tower and numerous other small additions.

In the design of the water improvements, aesthetic consideration was not neglected. The 500,000 gallon water tower, which it was found necessary to locate in the residence section, was set back on the lot and the intervening parkway landscaped under the direction of the Park Board. The high pressure pumping plant located along the main highway was built of buff brick, surmounted with a green

tile roof and the land adjoining graded and sodded. The well houses were constructed of brick and the entire installation given the finishing touches of a completed job.

In the construction work the coöperation of the contractors was most hearty and the city is indebted to them for the efficient manner in which the installations were made.

The general contract was handled by the H. L. Cannady Co., of Tulsa, Okla., and the water supply development by the Layne-Bowler Co., of Memphis, Tennessee, under their *"Water or No Pay"* guaranteed proposition.

RESULTS

The result secured by the development of the new ground water supply has proven most gratifying to the city. Not only has it eliminated the yearly expenditure of from $25,000 to $30,000 by the citizens for bottled water, but has materially reduced the operating cost and supplied a much better quality of water.

A comparison of the present water and that of the old supply is as follows:

	Filtered water supply p.p.m.	*Ground water supply p.p.m.*
Chlorine	212	28
Hardness	286	61
Total solids	753	123

In addition to the improvement in the quality of the water, the difference in elevation of the location of the wells and the old supply has reduced the pumping head from 230 to 178 feet, with a consequent reduction in the power. The abandonment of the filter plant eliminated the cost of chemicals and relieved the city of the labor of three filter attendants, resulting in the following saving:

	Savings per month
Power	$215.00
Chemical	$607.00
Labor	$375.00
Total per month	$1,198.00

This, it will be noted, is equivalent to $14,375 per year, which represents about $6\frac{1}{4}$ percent interest on the $191,000 invested in the water supply improvements, which, when taken into consideration with the saving of the expenditure for bottled water, represents a total saving to the citizens of about $40,000.

This saving represents an income of about 8 percent per year on the total cost of $491,000, which includes the original filter cost of $300,000 and the present ground water cost of $191,000. It is sufficient to pay the interest and create a sinking fund equal to the debt in about twenty years, which would seem ample justification for the substitution of the ground water supply for the filtered supply irrespective of the improvement in the quality of water.

The popularity of the new water supply resulting from the improvement in quality and through the 26 miles of extensions to the mains, has resulted in a more favorable attitude among the citizens toward other public improvements, which has manifested itself in petition for and the construction of about $\frac{1}{2}$ million dollars in sanitary sewers and about $1\frac{1}{2}$ million dollars in paving, bringing the city up to a high standard of civic development.

The application of the theory of securing adequate ground water supplies for the larger cities' use is one that will undoubtedly be given greater consideration in the future than in the past, due largely to the development of the modern type well and pumping equipment. However, this theory cannot be universally applied for there are locations where ground water supplies are impossible. The development of the filter plant has been almost equivalent to an act of Providence. It is not our desire to detract from the glory of the filter plants, many of which we have designed, but rather to point out the possibility of securing ground water supplies under certain conditions, methods of procedure in ascertaining the possible locations of such supplies, manner of development and such general information as might be of interest and service to fellow engineers in serving their clients.

SOME UNUSUAL CONDITIONS DISCOVERED THROUGH PITOMETER WATER WASTE SURVEYS[1]

By H. E. Beckwith[2]

In the thirty years our company has been conducting water waste surveys improvements in our methods of operation have come as often from the criticism and helpful hints of persons outside our organization as they have from the development of new ideas on our own part. Consequently, in calling to your attention those conditions which we have encountered in our work, I am not prompted by any unholy joy in pointing out the mote in my brother's eye. It is rather by way of returning in small measure the helpful courtesies shown us by the men in the water works field, and with the hope that you may find some helpful hint in the conditions we have found in other plants.

CLOSED VALVES

It is, of course, very common for us to find closed valves. Your attention is called to two such instances: In the first of these an entire town of some twenty thousand persons was being fed through four 6-inch mains, because a valve on the main 16-inch feed was closed. Moreover, this was the only valve in the entire system found closed, showing that care was taken to check up on the valves. Furthermore, and this is of special importance, it was the only geared valve in the system. When the operating nut on the gear was turned in a clockwise direction, the valve stem was turned counter-clockwise. As the valve stem on this valve closed in the same direction as all other valve stems in the system, it was necessary to turn the operating nut in the direction opposite to that of every other operating nut in order to close the valve. Someone failed to take this into consideration, with the result that the valve had been kept habitually closed.

[1] Presented before the Central States Section meeting, August 23, 1928.

[2] District Manager, The Pitometer Company, New York, N. Y.

In the second case, the hydraulic grade line was apparently lower at one point than it was at another point on the same line, three-quarters of a mile further from the source of supply. This was on the system of a small company serving several miles of territory with laterals feeding directly off one long main, or rather it had been one long main originally. For a mile and a half of its length it had later been paralleled with another main. This second main was tied to the original main at no place other than at its ends, and no laterals came off of it. A study was being made for the purpose of reinforcing the system. When the hydraulic gradient for the system, as determined in the field, was plotted on cross-section paper, it was found that midway between the ends of the two parallel mains the hydraulic grade line was lower than at either end. Subsequently, the valve on the reservoir end of the "old" main was found to be closed. All water being used along the mile and a half of parallel mains had to go to the farther end and then feed back toward the reservoir. Opening the closed valve, of course, took the sag out of the grade line and increased pressures below the point where the valve had been closed. The trouble in this case was caused by right and left-hand valves being indiscriminately sprinkled throughout the system. Volumes could be written about the trouble caused by the indiscriminate use of both right and left-hand valves in the same system. This is merely another example of the results of this practice.

DIFFICULTIES WITH SUPPLY MAINS

Speaking of hydraulic gradients, there is the case of the city whose officials had believed their system was being fed by two mains from the reservoir. A pitometer test proved, however, that there was no flow through one of these pipes. Further investigation showed that this main at one point actually lay above the water-level of the reservoir. After the line was lowered, its vacation was over and it went to work delivering water to the city.

Another very interesting case was that of a city which had originally been served by two separate companies. Later, these companies were merged and the distribution system was inter-connected. Each of these companies originally secured its water by gravity from a mountain reservoir, the reservoir of one company being 12 feet higher than that of the other company. Since the complete metering of this system a few years ago the meters through which water

was sold had accounted for a little less than 50 per cent of the water shown on the Venturi meters installed at the reservoirs. Our tests showed that during the night, when the use of water in the system dropped low, the water fed out of the higher reservoir into the lower. It is the nature of a Venturi meter to measure in a positive direction the water which goes through it, regardless of the direction of flow. Consequently, the water which fed from the higher to the lower reservoir was measured on each of the two Venturi meters, although as a matter of fact, it was never used in the distribution system at all. When the Venturi meters were originally installed the city was on a flat rate basis, and the waste of water was so large that it is doubtful if the water ever backed up into the lower reservoir. But with the metering of all the services the amount of waste gradually fell off until the condition prevailed of which I have just spoken.

Whenever a water system is fed by gravity from two or more reservoirs on different levels, it is well to grow immediately suspicious of back-feeding when the supply in the lower reservoir holds up better than the supply in the upper one.

INACCURATE METER READING

Another very interesting case was that of a small suburban city which purchased water from its larger neighbor by meter. As the city was being paid on its meters for less than half the water entering the distribution system, the water department had accumulated a large deficit. In addition to the conditions usually found by a survey, it was discovered that two 4-inch and two 6-inch meters were being incorrectly read, and that the city was being paid for only 10 per cent of the water going through them. The value of the water which had passed through the meters, but which had never been paid for, was nearly equal to the deficit of the department. An effort was made to collect this money on the grounds that the bills rendered the consumer bore the meter-readings and his acceptance and payment of the bills constituted an acceptance of the correctness of the meter-readings. As the department did not use a step rate, the matter of billing was comparatively simple. It is to be regretted that we cannot advise you as to the outcome of this attempt to collect, as we left the city before any settlements were made. Two of the consumers had, however, expressed a willingness to pay; and I understand that the state commission had ruled that any failure on the part of the city to collect the full amount would be equivalent

to the granting of preferential rates and would therefore be contrary to law.

This under-reading was caused by the fact that the smallest dial on the meters involved was graduated in units of one hundred, whereas the smallest dial on all other meters on the system was graduated in units of ten. The meter-reader entirely overlooked the necessity of investigating the meter to determine in what units it was graduated.

That this is not the only case of its kind is shown by the fact that another similar condition was recently found. As a remedy for this it is suggested that meter-readers be not permitted to take their previous readings on a meter into the field and so help to carry the error through. It is further suggested that the office clerks be forbidden to change any readings in order to make them conform to previous readings. Wherever a doubt exists as to the accuracy of the reading on a large meter, it would be well to have it checked by the meter company's representative.

In another suburban city, which also purchased its water through a meter, periodically the receipts from the water department would drop below the cost of its water. The trouble in this case lay in a compound meter to a steel mill. The high duty side of this meter was dead; and whenever business was sufficiently good with the steel company to cause a draught of water large enough to throw the flow onto the high duty side of the meter, business was very bad with the water department. Another factory in a different part of the city had been suspected of stealing the water, which is probably the one reason why the real cause of this lost water was not discovered before.

In the same place the larger city had metered two services, and had for years been collecting revenue from them, when, in reality, the services were attached to the mains of the smaller town. Both cities had mains in this one street. In this case, all moneys that had been so collected were turned over to the smaller town.

In another surburban borough which purchased water by meter, the newspapers stated that the leak discovered by the survey had been running for twenty-five years and had cost the borough in that time a quarter of a million dollars. This is not of particular interest here, except as it lends point to another statement made by the same news article. It seems that, when a large sewer was laid past this leak, it was impossible to handle the water with a pump. It was decided that a spring had been tapped and special foundations were put in to protect the sewer. It should be noted here that the leak

was from the open end of an abandoned service of which the borough had no record. In view of the known heavy losses, it is certain that the leak would have been discovered when this sewer was laid, had the water come from the direction of the main and not from the direction of a vacant lot.

It is remarkable how many springs, and swamps even, dry up after leaks on the water system are repaired. And how many people lose their source of valuable medicinal water.

UNAUTHORIZED USES

Several years ago, when the stock of privately owned water companies was more or less a drug on the market, and few companies had paid dividends in many, many years, we caused considerable consternation on the part of the president of one company where we were working. It developed that a certain manufacturing company in the city was getting about 100,000 gallons of water a day free, through a defective meter. The president of the water company was also president of this factory. It was bad enough, he felt, not to get any dividends on his water company stock, without having the dividends of his factory cut into by increased water bills.

In another case we were called in to locate the cause of a large amount of water escaping from the high pressure system of a middle sized city. By a quirk of fate, it was discovered that 300,000 gallons per day of water were being surreptiously taken from the system by a plant which was largely the property of the water commissioner. And he was the man who had been most instrumental in securing the commission for us in the first place. Certain it was that this water was being taken without his knowledge.

As a matter of fact, we find it generally true that, where water is being taken in an unauthorized manner, it is done without the knowledge or consent of the higher officials of the companies. It is usually some department head who wants to take a short cut to a good showing for his department.

LOW PUMP DISCHARGES

In recent years there has been a rapid increase in the development of electric power, with the result that many water plants have found it economical to substitute electrically driven centrifugal pumps for the old steam plant. Unfortunately, a full realization of the limitations of this type of pumping unit does not seem to have accompanied

its installation. In only too many cases the only requirement placed on the pump is that it pump water. No apparent consideration is given to the efficiency with which this work is done. The displacement type of pump allowed so much latitude in operating conditions that many plant operators have not yet come to a full realization that centrifugal pumps operate efficiently only under the design head, and at the design rate of discharge.

No branch of work being done by our firm is more interesting than the efficiency tests on electrically driven centrifugal pumps. In one instance the pumping units were 2 two and a half million gallon pumps, working in parallel to give a combined output of five million gallons per day. These pumps were designed to work against a head of 100 pounds. The time came when these pumps would not carry the maximum day load. So the output was increased by putting the discharge of these two pumps through a five million gallon pump designed to pump against a head of 50 pounds. This gave, then, an installation designed to pump five million gallons against a head of 150 pounds, whereas it was working against a head of only 100 pounds. This gave an increased rate of discharge, but at a considerable cost in efficiency. This was not the sole reason why the wire to water efficiency of the installation was under 44 per cent, as several pieces of wood were later taken from the ports of one of the pumps, but it did have a very important bearing on the loss of efficiency. It is of interest to add that, after disconnecting the 50-pound pump from the discharge of the two and a half million gallon pumps, and cleaning these latter out thoroughly, a subsequent test on these two pumps gave an over-all wire to water efficiency in excess of 70 per cent.

In another instance the clear well was of such small size that it was necessary to coördinate the flow from the filters into the clear well with the pumpage out of it. As the low lift pump from the river to the filters had a higher rate of discharge than had the pump from the clear well to the distribution system, this coördination between the two pumps was secured by partially closing a valve on the discharge of the low lift pump. This increased the head at the pump above its design head and induced a slip into it. So much was this increase in head and slip that the power required to pump the reduced flow was much more than would have been required to pump the greater quantity for which it had been designed, had it been operating under design conditions. Throttled down, the pump

had an over-all efficiency of approximately 30 per cent. A new low lift installation designed for a discharge equal to that of the high lift pump, thereby eliminating the necessity for throttling, gave, on test, an over-all efficiency of approximately 60 per cent.

Another city had been computing its pumpage on a false pump rating, a rating in fact about double the pump's actual capacity. This pump rating was so much in error that, had it been correct, the installation would have had a wire to water efficiency in excess of 100 per cent. And the secret of perpetual motion would at last have been found.

These cases are called to your attention in order to emphasize the necessity for the services of a reputable engineer when this type of installation is contemplated. With the decreasing cost of electricity, this installation is becoming increasingly popular. The efficiency of electrical units should be closedly watched. The greater efficiency being obtained from modern units will often be sufficient to warrant the installation of new equipment.

The speaker recalls one instance where the replacement of an old installation having an over-all efficiency of 57 per cent with a modern unit having an over-all efficiency of 72 per cent decreased each monthly power bill an amount equal to 5 per cent of the total cost of the new installation.

Then there was the centrifugal pump whose 10-inch discharge line was reduced to 6 inches for a few lengths of pipe. The explanation given for this novel procedure was that the water pressure would be increased after going through the smaller pipe. This reasoning sounds strange to us today, but one of our engineers, delving through the council records of a city where he was working, found a case equally interesting.

Some sixty years ago when our knowledge of hydraulics was not as extensive as it is today, an engineer had been employed to design a main between the reservoir and the city. This main was partly 20 inch and partly 18 inch, fed by a 12 inch from the reservoir. The engineer in charge of the work was the author of the following interesting explanation:

This main line of pipe was enlarged by the direction of the Committee on Water under the light head at the Westerly end, to render the same much more effective as a means of conveying and delivering water at the extreme end of the pipe here in the city. Since the lighter the head, the larger is the required diameter of the pipes necessary to furnish the amount of water conveyed

by the small pipe under a much greater increase of head; this change has been one of much utility in increasing the efficiency of this supply main.

Within ten years after the main was put in service, the supply in the city became so deficient that the main was not full at all times. The report of the Water Committee says:

While the discussion was going on about the High Service, the Engineer discovered that the main pipe already laid was wrong end first, and that the advantages of having a small pipe near the reservoir to fill and supply a larger one in the city, were not so great as he at first supposed.

These are only a small part of the interesting conditions found in our thirty years work.

DISCUSSION

D. C. Grobbel (Detroit, Mich.): All pitometer papers are very interesting and Mr. Beckwith's is certainly one of the top ones.

I do not entirely agree with his conclusion. I hope it is not an ex-cathedra pronouncement that we have to follow in not permitting meter readers to have the previous reading. That may be all right in a privately owned water works system, but in a municipally owned system, we have another viewpoint. We want our meter readers to have the previous reading. We want to check up on the consumption, and it saves a considerable amount of money to a department where they do not have to send out for check readings continually.

Take an eight-room house with a consumption, say, of five hundred cubic feet per month, to be specific. The meter reader has his book and it shows that reading. Probably the third quarter in the year he runs up against a condition which indicates, from his knowledge in the book, that the owner of the premises is using one or two thousand feet a month. That may be satisfactory for a private company, possibly, but for a municipal concern we want to be able to ask the people why they use so much more water? Our meter readers must be in a position to check that reading. They make an investigation and find that a toilet has been or is leaking. An underground leak might be in existence. For that reason our department insists upon having the previous reading.

To eliminate the contention of Mr. Beckwith that the indicator was wrong, it seems to me the height of folly for any water department or company to take a meter from the shop and set it on a line

without testing that meter. It would be out of the question for a test not to show that that indicator was wrong. The head should certainly indicate that.

I agree with Mr. Beckwith in all he has said as to the desirability of the pitometer tests. We have gone so far as to set up a pitometer crew of our own, two crews, in fact, to carry on continuous work in the pitometer survey. Furthermore, we thought enough of the pitometer company to make a special deal with them last June to make a special investigation for us in the downtown district. But I do not agree with his conclusion that the meter reader should not know anything about the meter readings.

Mr. Whysall (Marion, Ohio): I think the missing link is in the store room. I assume you all have a store room or something which is the equivalent thereto. When the meters come in they should all be gone over by someone connected with the organization. Most of this trouble arises with large meters. They are not fixed for testing. You can make a test of any meter, no matter how large or small the flow, and the meter tester will then discover that the dial on the large meter is quite different from the dial on the small one. Most of the plants in the Central States Section area are equipped with meter-testing apparatus.

I do not understand why so many of the plants continue to have right and left-hand valves. I really believe that some of the fellows think that in order to make the change they have to take that valve out and put in a new one, whereas all that is necessary is a new stem and a new nut. It is a job that can be done easily if your standard opens to the left. It should give no trouble for, when you order you order right and left. The notation refers to the spur pinion and not to the gear on the stem.

Mr. Beckwith: I think Mr. Grobbel misunderstood me. The meters read correctly. There was no mistake in the meter dials. If the meter had been read correctly there would have been no trouble at all. But the small hand was 100 feet and was so marked, but the meter reader overlooked the necessity of finding out whether it was one hundred or ten feet. It was absolute carelessness.

In the second case, I found that in the office when the meter readings showed a great difference they were changing them in the office to conform with the previous readings.

Mr. Young (Chester, Pa.): Probably Mr. Beckwith can enlighten us. We have a 6 by 3 detector which we are furnishing a baking company. They have their fire hydrants on this line and they also use it for their break-down system. The 3-inch takes care of it up to 65 gallons a minute and the 6-inch does not come in until 400 gallons have been used. In the circular describing this meter, it is indicated as very accurate on a small flow, but there is a point between 65 and 400 gallons a minute that would bankrupt any small water company. We have not solved the problem of this registration.

Mr. Beckwith: We certainly have run into a number of those cases. About the only thing to do is to separate the fire from the domestic or industrial service. You will find that at sixty-five gallons a minute you are getting every drop of water that flows through it, but from that point up is where the difficulty arises. The only other meter made is the Dreyer protector and that leaves a lot to be desired. The manufacturers simply have not solved that problem yet. Until they do, the only thing to do is to separate those two services. They will either have to put in a separate fire or a separate industrial service, and then put on a register meter in the domestic service.

Mr. Davis: I should like to ask Mr. Beckwith whether he has had any experience with the use of flow meters on fire lines, and whether the underwriters would object to the use of that type of meter providing that the ratio between the smaller and the larger diameter is fairly large; that is, say on the ratio of about a 6 to an 8-inch pipe.

The reason I ask is that in some recent experiences in the testing of large meters, we discovered exactly the same situation that Mr. Beckwith and Mr. Young have spoken of, namely, on detector meters of two different types, the flows were in almost all cases considerably below the actual amount of water that was passing through. In two cases the large meter refused wholly to operate until it was cleaned, and upon cleaning the registration in one instance was about 85 per cent of the total amount of water passing through.

The possibility of using the flow type of meter under conditions where the low flows would be in excess of 25 per cent of the large or average flow is a consideration that is possible, I believe, providing

no objection is raised by the underwriters. I wonder if Mr. Beckwith has had experience with that.

Mr. Beckwith: I have not. I recall one instance of a combined service where we ran a three weeks test on the meter. Certain small and certain high flows were registered correctly. We ran this three weeks' test and it showed that 32 per cent of the water flowing through it was registered. Based on dollars and cents, it meant the city had lost very nearly $17,000 on that meter. It happened to be one of the largest cities in the country. We were anxious to make a showing, and the first thing I did was to look over all the meters. I passed this thing up because there was nothing on the surface to indicate that there was any trouble there. That was the last thing I looked at and then I had to stay over two weeks to straighten the matter out. In this particular case the factory was outside the city limits and in order to save taxes they were getting their water from a belt line. They owned the meter and the attitude of the city was that the company was responsible for the condition of the meter. The city sent a bill for nearly $17,000, and they collected.

C. H. Wetter (Tiffin, Ohio): We had a fire line meter on an orphans' home that used considerable water. We knew they were using more water right along, but our meter registration did not show it. We took it out and put in a Trident Crest and used a 2-inch by-pass. We left the by-pass meter off because we knew the bill was going to be high enough without getting every drop of it when we rendered a bill with the new meter. We read the meter every day for ten days and sent in an estimated bill for $700. They had been paying $200. The 6-inch meter registered absolutely correct on the 1-inch flow and they considered that good enough. Later on we used the 2-inch by-pass meter. When we opened that up the registration fell off. We took off the by-pass and the registration went back where it was. We experimented back and forth and we never got as good registration with the compound meter on as we did without it. Eventually we took it off. To get the exact figures you have to put it back and keep a record.

We have had other cases. The Y. M. C. A. filled their swimming pool three times before we knew how much it held. Every time they filled it, it did not register. We took the meter out and put

in a 2-inch disk meter, and instead of collecting \$20 or \$30 we are now collecting from \$60 to \$80 every two months.

We had a 3-inch compound meter in a school house and we did not get any registration. It was a 5-inch pipe with a $\frac{5}{8}$-inch pipe head. We brought in a $\frac{5}{8}$ meter and tested it out in the shop and it worked all right. We plugged up the compound meter and now we are collecting a bill of \$20 every two months where before we were not getting anything. There was no registration at all, either on the large or the small meter. Why that $\frac{5}{8}$ meter did not register when we put in the compound meter, I do not know, but it did not. When we put it in the shop it would run. The only way we can keep the compound meters running is to go around every two weeks and tune them up. That is pretty strong, perhaps, but I would say every few months, unless it is somewhere where the big meter is called into use every few days or so. Where they stand without running we have trouble.

There is a detector meter on a factory and we have a low pressure to fill that tank. I noticed we did not have any registration on that meter and we got busy and cleaned it up. Ever since then we have been collecting \$40 or \$60 on that meter and they claim they have no consumption. We never have been able to find any, for the average 4-inch takes care of it, but there is always a bill of that size. Where the water is going I do not know. Before that we got nothing.

I have had no success with compound meters. My opinion is that anything under three inches does not require a compound meter anyway.

All our fire lines are metered. We had one factory that used water off its fire lines for a number of years. In order to force another party to put in a domestic line, we had to go to that place and place another meter so that they would take their water supply through a separate meter. We placed a 2-inch Trident Crest. It never equalled the reading on the Hersey reading so we always billed on the Hersey reading. Eventually they took their whole supply on that line and we did not have any more readings on the fire line meters. We had a compound meter in for a while and took it out and put in a 2-inch disk and a by-pass so that we could compare it at any time without shutting them off, for we cannot very well shut them off.

H. E. Watt, (Huntington, W. Va.): This discussion interests me very much because my experience with the 2-inch compound meter

is directly the opposite of that given by Mr. Wetter. You say you clean up the 2-inch meters about every two or three weeks. What kind of a sediment do you get in there? What causes the meters to stop registering?

C. H. Wetter: On our compound meters there is not enough difference in the flow. Probably the small meter is registering the water for six months or so in the year without the large meter being called into commission. Consequently there is corrosion and the meter sticks. If you have a meter that flops back and forth it stays as clean as the small meters which are running right along. A person has to know on what kind of a service to put a compound meter.

MECHANICAL AGITATORS FOR THE KNOXVILLE WATER WORKS[1]

By W. W. Mathews[2]

Knoxville, Tennessee, placed its new water works plant in operation September 1, 1927. It comprises an intake, pumping station and filter plant and coagulation basins. In addition to the plant, two concrete reservoirs were added to the system, having capacities of 1 and 10 million gallons respectively. Large feeder mains were also laid to strengthen the distribution system.

The source of water supply is the Tennessee River and the intake is located about 3 miles down-stream from the junction of the French Broad and Holston Rivers.

Water from the French Broad River is soft, carrying colloidal clay and color caused by industrial wastes most of which are organic. Considerable industrial waste finds its way into the French Broad River from the works of the Champion Fibre Company which discharges daily large volumes of soda liquor, sulphite and sulphate liquor and vegetable carbon. The quantities known to be discharged are listed in table 1.

All of the industrial waste from the above plant is discharged into the Big Pigeon River which empties into the French Broad River about 140 miles above Knoxville. Even after being diluted, these wastes are noticeable at the water works intake, tending to increase the natural colloidal conditions of the water in the French Broad River. Hardness, turbidity, color, odor and taste are increased by the introduction of the wastes into the stream.

Samples taken in the Big Pigeon River above and below the plant of the Champion Fibre Company show the effect of the industrial wastes. Analyses of these samples are shown in table 2.

In addition, there are several tanneries located on the French Broad water shed which discharge appreciable amounts of tannery wastes.

[1] Presented before the Water Purification Division, the San Francisco Convention, June 14, 1928.

[2] Assistant Engineer, Alvord, Burdick and Howson, Chicago, Ill.

Samples for mineral analysis, 6 each, were taken between December 21, 1924 and September 18, 1925. They indicate the range of chemical content in the water of the French Broad River. These samples were taken just above the junction of the French Broad and Holston Rivers. The results are shown in table 3.

The water of the Holston River is hard and clear and is characterized by inorganic wastes and of the two waters is the easier to

TABLE 1

Industrial wastes discharged by Champion Fibre Company

Lime carbonate waste	4 to 5 tons daily
Vegetable carbon	12 to 15 tons daily
Bleaching sludge	1 ton daily
Soda black liquor	30,000 gallons daily
Sulphite waste	Indefinite, but very large

TABLE 2

Analyses of samples from Big Pigeon River, above and below plant of Champion Fibre Company

LOCATION	ALKALINITY (HCO_3)	COLOR	TURBIDITY	CHLORIDE	ODOR
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	
Above plant	14	15	30	1	None
Below plant	64	200	200	24	Very disagreeable

clarify. The principal waste discharged into the North fork of the Holston River is from the Mathieson Alkali Works at Saltville, Virginia.

The main constituents of this waste are shown by the following analyses.

	p.p.m.
Calcium hydroxide	1,480
Calcium sulphate	1,330
Calcium chloride	84,000
Sodium chloride	54,000

Approximately 900,000 gallons per day are discharged into the river.

Mineral analyses, six each of water from the Holston River taken just above the junction with French Broad River and taken at

the same time that samples were taken from the French Broad River as shown in table 3, are shown in table 4.

The ratio of discharge of the Holston to the French Broad River is approximately 3 to 5 and the intake is located on the Holston side of the Tennessee River. In general, the water at the plant is an average of the two waters, although at times one or the other predominates.

The combination of the two waters offers a water easier and more economical to treat than either one separately. If French Broad water alone were treated, the alum dosage would have to be increased

TABLE 3

Analyses of samples, French Broad River (six each from December 21, 1924 to September 18, 1925)

CHARACTERISTIC	MAXIMUM	MINIMUM	AVERAGE
	p.p.m.	*p.p.m.*	*p.p.m.*
Color	60	10	20
Turbidity	20,000	50	350
Alkalinity	70	30	50
Hardness	95	25	55
Total solids	170	60	125
Loss on ignition	60	20	40
Silica	31	5.5	11
Oxides, Fe and Al	10.5	2	3
Calcium	27.2	14.5	17.4
Magnesium	8.9	1.5	3.5
Sodium	7.4	2.3	3.2
Sulphate	11	3.3	6.5
Chlorine	20	3.0	8
pH value	7.4	6.8	7.1

and lime used in combination with the alum. Color removal would require that the dosage be increased and lime would be necessary to counteract the free CO_2.

If Holston River water were treated alone, hardness would present the principal objection and part of this would have to be removed to make the water acceptable to industrial users. At present, one of the large industries located on the Holston River near Knoxville has a small filtration and softening plant, alum and soda ash being used. The deterioration of boiler tubes is presenting such a problem that a careful study is being made to correct the corrosive action of this water.

The water in the Tennessee River, as treated by the City of Knoxville, has presented no such problem.

Colloidal and organic impurities from the French Broad River require a somewhat larger chemical dosage at Knoxville than is required in most purification plants of this character.

MECHANICAL AGITATORS

After a careful study had been made of the water to be treated, which was available from records kept by the Knoxville Water Department, it was evident that a mixing device was required that

TABLE 4

Analyses of samples, Holston River (six each from December 21, 1924 to September 18, 1925)

CHARACTERISTIC	MAXIMUM	MINIMUM	AVERAGE
	p.p.m.	*p.p.m.*	*p.p.m.*
Color	17	1	8
Turbidity	10,000	5	125
Alkalinity	111	100	105
Hardness	163	111	130
Total solids	400	180	200
Loss on ignition	85	30	50
Silica	11	5	8
Oxides, Fe and Al	8.5	1.2	2
Calcium	52.4	34.7	45
Magnesium	17.6	7.6	11
Sodium	30	11.6	24
Sulphate	8.3	6.6	7.2
Chlorine	130	20	70
pH value	8.4	8.0	8.2

would permit varying the period and violence of the mix on short notice. Mechanical agitators were chosen in that elasticity of operation could be effected with simplicity and ease of control.

The mechanical agitators consist of two circular reinforced concrete tanks 30 feet in diameter and 20 feet deep in which is placed the stirring mechanism. The mixing period is twenty minutes, using both tanks when the plant is operated at a 15 million gallon rate. Piping to the tanks is arranged so that the tanks can be used singly, in parallel or in series. Raw water enters the tanks at the top and flows out through a 42 inch square opening in the floor of one

tank, the opening being placed as near the center of the tank as the shaft supporting the mixing apparatus will permit. About one-third of the water surface in each tank is visible.

The stirring device is on the same general plan as that used in installations of this character. A center shaft of 6-inch pipe carries a cross arm of $2\frac{1}{2}$-inch pipe on which are suspended paddles. These paddles are of steel $\frac{1}{8}$-inch thick and the area of the plates is slightly more than 25 per cent of a vertical diametrical section.

Power for operating the stirring device for each tank is from a 3 h.p. D. C. motor and speed variation in the motor is obtained

TABLE 5

Chemical cost per million gallons, in dollars

	1926*	1927†
October	9.36	6.96
November	9.31	5.47
December	7.57	4.53

* Old plant.
† New plant.

TABLE 6

Alum dosage, in grains per gallon

	1926*	1927†
October	3.34	2.26
November	3.43	2.07
December	2.89	1.72

* Old plant.
† New plant.

by field control. This ranges from 650 to 1950 r.p.m. A further reduction in speed is effected by a reducing gear and by a combination of chain and sprockets driving bevel gears. Specifications called for a variation in speed of from 0.4 to 1.3 r.p.m. of the mixing apparatus which is equivalent to 0.6 and 2 feet per second peripheral velocity respectively.

Experiments conducted at the plant show that, when water from the French Broad River predominates in the Tennessee River, the best results are obtained by operating both tanks in series and with the stirring device rotating at 1 r.p.m. With the Holston River

water being treated, a short rapid mix gives the best results. When the French Broad and Holston Rivers are at such a stage that the water is about evenly mixed, the tanks are operated in series, and the agitators operated at an average speed of 1 r.p.m.

Chemical feed piping is so arranged that alum or lime can be fed to either tank and so that lime can also be fed into the clear well. At times, it has been found advantageous to apply the alum ahead of the lime and at other times the best results have been obtained by applying the lime ahead of the alum.

The tanks are constructed so that, if it is desired to reverse the direction of flow through the tank, it can be effected easily. Operating experience of the past six months shows that the present method of operation is satisfactory and no deposits have occurred in the tanks. The turbidity range is from 50 to 10,000, with an average throughout the year of 800 p.p.m.

Comparisons of chemical costs of the last quarter of 1927 operating the new plant, with the last quarter of 1926 with the old plant in operation, show that there has been a saving in chemical costs of $1,700.00 plus treating water of similar character. A substantial saving in chemical costs was to be expected for the new water works supplants one of the oldest filter plants in the country, which has been operated under an overload for several years.

The cost of chemicals per million gallons for the last quarters of 1926 and 1927 is shown in table 5. This includes the cost of lime, alum, soda ash (used experimentally in 1926), ammonia and chlorine.

Alum is used as a coagulant with lime being added at intervals as the character of the water requires. This is such a small percentage of the alum used that table 6, showing grains per gallon used in the same period listed above, gives an idea of the reduction effected in chemicals by the mechanical mixers in the first 3 months of operation of the plant.

All of the water works improvements were carried out under the direction of Frederick W. Albert, Engineer in Charge of Water Department. Alvord, Burdick and Howson were Consulting Engineers for the City of Knoxville and the writer was Resident Engineer for the above firm.

MAINTENANCE OF METERS[1]

By Frank J. Murphy[2]

Next to the provision of an adequate supply of water and its efficient and economical distribution, there is no more serious problem confronting the water utility official than the conservation of that supply without unnecessary restriction and its distribution upon an equitable and economical basis. In that conservation and distribution of the supply there is no factor of greater importance than that of meterage of the system.

Universal meterage, though desirable, is, not alone sufficient. For the utmost efficiency and economy, careful consideration should be given to the selection of the type of meter, its operation and record control.

The meter should be adequately sized but not oversized, it should have the capability of meeting the quick and changeable volumetric demands of the service. It should be so constructed that wear of parts is minimized. And, finally, it should be capable of continuous registration of all flows through the meter.

Since the revenue of the utility is dependent upon the meter, it is essential that its operation be closely supervised. In that, the frequency of meter reading, record control and accuracy tests play no small part.

Frequent meter readings insure the utility against lose of service, reduce the period of non-registration of the meter and enable the utility to obtain a closer and more equitable accounting of its supply. They protect the consumer from high water bills through wastage or leakage, frequently unknown to him.

Record control is the warning signal of the system. Registration inaccuracies are readily discernible through a system of registration records. Comparisons can be made with previous readings or with those of corresponding periods of previous years. Material increase or decrease of registration should demand an investigation of the conditions and possibly a test of the meter.

[1] Presented before the Wisconsin Section meeting, October 11, 1928.

[2] Superintendent, Division of Meters, Water Department, Milwaukee, Wisc.

Accuracy tests and inspection of meters are equally of great importance in the accounting of the supply. Character of the water supply, service demands and other conditions should be the determining factors relative to the frequency of meter test and examination.

MILWAUKEE PRACTICE

Milwaukee has striven to solve the problem of the conservation and equitable distribution of its water supply by almost universal meterage and the selection of two types of meters for its water service, namely, the disc meter type up to the 2-inch size and the compound type for larger services. While splendid results have attended their efforts during the past several years, it is confidently believed that better results could be attained were the utility not handicapped by its system of private rather than of municipal ownership of meters.

In the fifty years of meterage Milwaukee has accumulated a variety of meters. Many of these are unsuitable for the variable requirements of the service and are tolerated only because the department does not choose to incur the enmity of the public in ordering a change.

With 85,221 active services of which 84,217 are meter controlled, 146 controlled by hydraulic elevator indicator and 858 unmetered, Milwaukee is rated as 98.8 per cent metered city. The 858 unmetered services consist of 556 automatic sprinkler services and 304 public bubbler and boulevard grass center plot sprinklers.

Disc meters from $\frac{5}{8}$ to 6 inch constitute the majority of installations, 71,519 representing 84 per cent; Worthington duplex piston with 11,969 are 14.2 per cent while the remaining 0.8 per cent are represented by 163 current, 486 compounds and 8 fire service meters.

Nine manufacturers' meters are in service, one manufacturer having 41.7, another 22.7, a third 19.7, while the remaining 15.9 per cent is divided among six manufacturers.

The Division of Water Meters and Services under whose supervision these meters are placed has a force of 29 employees. With the superintendent, four clerks and an inspector of water waste constitute the office division. The Shop and Field Division has a foreman, stock clerk, machinist, twenty meter repair men and a porter. Eleven meter repair men and the machinist are assigned for shop repairs, and nine repair men attend to the field work. One two-men crew makes the new meter installations, one two-men and two one-man crews handle the meter removals and resets, two re-

pair men the field repairs and one the consumers complaints. Six Ford roadster trucks and one Ford one-ton truck are assigned the field operatives.

Forty meter readers, under the jurisdiction of the Division of Collections, read the low consumption meters monthly, high consumption bi-monthly, and construction purpose meters weekly.

The ordinances of the City of Milwaukee obligate the property owner or consumer to install and maintain the water service and meter under supervision of the city. The meter must be the size of the tap or branch connection with the main. Its location must be on or above the basement or ground floor of the building if not more than 50 feet from the lot line. If more than 50 feet distant, the installation of $\frac{5}{8}$ and $\frac{3}{4}$ inch meters must be made in a 20 inch clay pipe pit 6 feet in depth, uncovered bottom and meter extended within 22 inches from top of pit. Larger meters are installed in concrete pits with sewer connection.

All meter cocks and couplings for the $\frac{5}{8}$, $\frac{3}{4}$ and 1 inch meters are Milwaukee Water Works pattern and must be purchased from the Department.

Meters of $1\frac{1}{4}$, $1\frac{1}{2}$ and 2 inch are installed with two gate valves and unions and 3, 4, and 6 inch with two gate valves and a 2 inch test valve between the outlet side of the meter and the outlet valve.

All meter connections must be provided with sufficient play or swing to permit easy installation and disconnection.

Meters of the $\frac{5}{8}$ to 2 inch size must be disc type; those of larger sizes the compound type.

The meters must conform with the specifications of the Department which are practically the same as those of the American Water Works Association. The manufacturer's serial number must be stamped on the outer case or housing in addition to the lid.

Disc meter test rates conform with the American Water Works test rates. Compound meters must test 2 per cent plus or minus from the highest to the lowest or $\frac{1}{32}$ inch stream flow, with a 3 per cent allowance on the breaking or alternating point. This point of alternation in the operation of the two sections should be between the $\frac{1}{4}$ and the $\frac{3}{8}$ inch flow for 3 and 4 inch and between $\frac{3}{8}$ and $\frac{1}{2}$ inch for 6 inch meters. The valve operation should be positive; that is, there must be no continuous operation of the small section meter, though a slight creepage not to exceed one foot in 100 is not objectionable.

Meter Repairs

The installation and removal of meters is made only by the Division of Meters.

Meters are repaired on the premises or removed for shop repairs as the nature of the complaint necessitates. Minor defects such as spindle leakage, dirty dials, broken glass, connection leaks are field repairs. Large meter defects are also assigned to the field repair men. These repairs are generally cleaning screen, dial defects and gear train renewals.

Major complaints such as non-registration, low pressure, change of location, abandonment of meter and test requests are referred for meter removal and shop examination.

Here is where the system of private ownership works to the disadvantage of the department, increases cost of operation and prolongs the period of non-registration of the service.

While the Department has the privilege of removing the meter at any time, it cannot substitute another meter but must return the identical meter to the service after repairs. During this time the service is maintained by the insertion of a filling or connection pipe. Nor can the Department make any repairs involving the installation of new parts until the owner has been notified of the nature of repairs and authorized such repair.

As a consequence, meter repairs are divided into two classifications or accounts—the "Chargeable" in which the owner is charged for the installation of new parts and the "Non-Chargeable" in which no new parts are installed and the Department assumes all expense for cleaning and adjustment.

Every meter brought in for repair is first tested, if capable of registration, before disassembling. It is then examined and if no new parts are required it is immediately repaired and set aside for reset. This is a "Non-Chargeable" account.

If, on the other hand, the examination shows necessity of installing new parts, such parts are listed, the owner or occupants notified and furnished an estimate of the repair cost with the request that he sign and return the repair notice authorizing the repair at his expense. On receipt of the order the meter, which had been reassembled and set aside awaiting the order, is again disassembled and repaired. No time charge is entered for the removal, examination or reset. This is the "Chargeable" account.

Of the 18,438 meters repaired in the field and shop in 1927, 77.3 per cent were on the "non-chargeable" and 22.7 per cent on the "chargeable" basis. There are no short cuts in the meter repairs. Except for the factory rebuilding of some worn gear trains all defective parts are scrapped.

All new meters of the flat disc model are factory equipped with one piece discs but in the repair of old meters the three piece type of disc is used as far as possible. This, it is needless to say, is a saving to the consumer as the filling of the disc balls obviates a chamber replacement.

Sedimentation from the mains entering the meter causes a large proportion of meter defects. Hot water caused approximately 5 per cent of the meter trouble in 1927. This defect is more prevalent during the warm season and is generally caused by careless operation of the gas heater attached to the boiler.

Whenever a meter is listed as "disc warped" the owner or occupant is notified of the condition and probable cause. No remedy is suggested unless he requests, or the defect is of frequent occurrence. The remedy suggested is first to exercise ordinary judgment in the operation of the heater, but, if a mechanical contrivance is used, put a check valve and a good springless relief valve on the cold water inlet to the boiler.

The Worthington duplex piston meter is without doubt the most bothersome meter we have as far as handling and repair is concerned. It is a heavy cast iron meter weighting about 75 pounds in the $\frac{5}{8}$ inch size. Incapable of drainage it cannot be moved during the cold weather. Practically all the parts are cast from our patterns and machined in our shop as it is impossible to secure the parts from the manufacturer. The average repair consisting of rings, valves and valve seats takes about $6\frac{1}{2}$ hours for the $\frac{5}{8}$ inch meter. It is a substantial meter capable of long wear for ordinary service, but has less delivery, more loss of pressure and noisy operation than present day meters. In this meter there is particularly great need of watching the registration reports and of testing the meter at stated periods. The construction is such that a larger percentage of slippage is present in this than any other meter before registration ceases. This meter has been known to show an under-registration of as much as 50 per cent.

Meter tests

In the shop test of meters seven Mueller test machines are used for the $\frac{5}{8}$ to 2 inch meters and for the larger meters a tester of the Meter Division design is used.

Each Mueller tester has its individual 15 cubic foot tank set on scales and discharging on the floor of the curb enclosed test rack to a catch basin below. Each tester has a 2 inch water supply under 45 pounds pressure.

The larger meter tester has a 6 inch inlet with a 3, 4 and 6 inch branch separately valved with quick operating valves. The outlet side has corresponding openings separately controlled by wheel gate valves. These branches discharge to a single 6 inch pipe which is carried to a height of 6 feet and horizontally 8 feet then dropping through a curb protected slot to a 285 cubic foot tank in the basement. The horizontal discharge pipe is supported by an overhead trolley. This trolley arrangement permits an outlet adjustment or "spread" from 9 to 102 inches. The outlet valves are by-passed with a 2 inch Mueller multiple test valve. The 285 cubic foot tank sets on a 10 ton scale with beam extended to the test floor. The tank discharge to the sewer is controlled by a drop valve connected to a lever at the test floor. This tester will test any meter from 9 to 102 inches in length on stream flows from 6 inches to $\frac{1}{32}$ inch under 45 pounds pressure.

New meters are accepted on a basis of 2 per cent for the major and 10 per cent for the low flows, although in the service and repair tests a $1\frac{1}{2}$ per cent variation is the practice.

As previously stated compound meters must have an accuracy rate of 2 per cent on all stream flows excepting that of the "breaking" or "change over" point of operation, at which point a 3 per cent allowance is made.

Old meters of the current type are passed on a 10 per cent low flow rate of $\frac{1}{4}$ inch for the 3 and 4 inch sizes and 10 per cent for the low flow rate of $\frac{1}{2}$ inch for the 6 and 8 inch meters. For the disc meters 10 per cent is given on the $\frac{1}{8}$ inch flow for the 3 inch and the same allowance on the $\frac{1}{4}$ inch flow for 4 and 6 inch disc meters.

Field tests are made on meters larger than 2 inches.

It is the policy of the Department to test and examine all large size meters once a year, unless the registration is uniformly low in which case the meter is tested every two years.

The field test equipments are a 3 and a $\frac{5}{8}$ inch Lambert disc meter, both with quick closing valves, eight orifices of 1, $\frac{3}{4}$, $\frac{5}{8}$, $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$ inch sizes and 200 feet of $2\frac{1}{2}$ inch high test hose.

During the test period the "master" or test meters are tested every three days to insure accuracy maintenance. The master meters are connected to the test valve by means of the hose and the service outlet valve closed. The 3 inch meter is used for all streams down to the $\frac{5}{8}$ inch at which point the small test meter is substituted and orifice flows of $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$, $\frac{1}{8}$, $\frac{1}{16}$ inch are checked by the small test meter.

TABLE 1

NUMBER OF METERS	REGISTRATION	NON-REGISTRATION	PER CENT UNDER-REGISTRATION (AVERAGE)		
			$\frac{3}{8}$ inch	$\frac{1}{8}$ inch	$\frac{1}{16}$ inch
	cubic feet				
43	100,000	18	(25) 2%	(8) 13.6%	(17) 25.8%
45	100,000 200,000	13	(32) 2.5%	(11) 12.4%	(21) 17.6%
10	200,000 300,000	4	(6) 4.4%	(2) 11.6%	(4) 9.6%
1	300,000 400,000	—	(1) 1.7%		(1) 15.2%
1	400,000 500,000	1			
100		36	(64) 2.6%	(21) 12.5%	(43) 14.5%

One hundred feet runs are made on the high stream flow, 10 feet on all other flows except the $\frac{1}{8}$ and $\frac{1}{16}$ inch on which 2 feet runs are made.

The service meter must check with the master meter. After the test the meter is examined to determine the interior condition.

In 1927, 254 large meters were tested and showed an average net under-registration of 3 per cent. One hundred and seventeen were disc and current type meters in which the net under-registration was $\frac{2}{16}$ per cent but no registration below the $\frac{1}{4}$ inch orifice flow. Of the 137 compound meters tested, 38 tested 100 per cent, and 99 showed a net average under-registration of 0.84 per cent. And this is on all orifice flows from the highest to the $\frac{1}{16}$ inch. This low rate of

under-registration of the meters is the result of annual test and examination.

Milwaukee has been lenient in the enforced abandonment of the old type meters. It has likewise been lenient in the enforced repair of meters at the consumers' expense unless that meter failed entirely in registration. For this reason no periodical tests of small meters has been carried on. In other words the department prefers to stand the slight loss by reason of the under-registration of the meter rather than incur the ill will of the public in ordering a repair on a meter that registers the major portion of the water service.

Recently, however, a test was conducted on meters that had not been in the shop for a number of years.

One hundred $\frac{5}{8}$ inch meters were taken at random, the records showing no shop entry for twenty years or more. These were residential meters and represent the product of nine manufacturers.

The test record classified according to registration is given in table 1.

Of the 100 meters tested, 36 failed to register on full flow. Of the remaining 64, 43 showed varying degrees of accuracy to and including the $\frac{1}{16}$ inch stream, and 21 down to the $\frac{1}{8}$ inch flow.

In 1927, 4746 new installation meters were tested, 195 being rejected as failing to meet test requirements, 266 installations withheld as incomplete and 4285 installed, making the total active meters 84,217.

The total number of meters repaired and serviced was 18,438, representing 21.8 per cent of the meters in service.

The net cost of operation of the Division of Meters for all meters in service was 46.3 cents per meter.

REPORT OF THE METROPOLITAN WATER BOARD OF LONDON[1]

A Review

By Norman J. Howard[2]

The remarkable circulation of the reports of Sir Alexander Houston, extending as they do almost round the entire world, is possibly the most eloquent tribute to the scientific and literary value of the reports. In America, the publications of the London Metropolitan Water Board are yearly anticipated, not only on account of their uniqueness, but for their practical value. On numerous occasions they have been of material value in aiding in the solution of different problems arising out of the treatment and purification of public water supplies.

In previous years the history of some of the sources of London's water were given. The current report includes the illustration of the River Lee as a source of supply. A study of the text and reference to the photographs, reproducing as they do many historical pictures and nature studies, will enable the reader to take a romantic journey through some of the most beautiful English scenery along the banks of the River Lee from its source to the purification works, where a total of 62 million imperial gallons is daily extracted. This represents a little less than one-quarter of London's supply. In the Lee valley artificial storage reservoirs cover 904 acres and hold in the aggregate 5541 million gallons.

The introduction includes many expressions of literary value rarely found in a report of a technical nature. Sir Alexander states:

> All water supplies are exquisitely romantic. Water evaporates from the ocean and condenses to form clouds. The clouds burst, and millions of drops of rain, the jewels of heaven, fall on the mountains and kindly valleys to give

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[1] Twenty-second Annual Report on The Results of the Chemical and Bacteriological Examination of the London Waters for the Twelve Months ended December 31, 1927, by Sir Alexander Houston, Director of Water Examination, Metropolitan Water Board.

[2] Director, Water Purification Laboratories, Toronto, Can.

us our springs, lakes, rivers and subterranean sources of supply. . . . . Speaking more particularly of our polluted water supplies, there is another kind of romance which, if it runs in less exalted channels, is, in its way, none the less remarkable. It is the glory of achievement, the power of rendering initially impure sources of supply palatable and safe for human consumption. Progress in this direction has been phenomenal within recent years. . . . . A great river flows daily through London's thousands of miles of water mains; every drop of it in its origin borrows from the purity of the ocean and the clouds of heaven; the Chilterns, Cotswold and other great hills send on to the peaceful valleys the fruits of the sky; then, alas, come the unwelcome contaminations associated with the growth of population and of manufacturers; but finally comes the romance of purification, the gigantic reservoirs, the amazingly effective chlorination processes, and the great array of filter beds with their billions of grains of sand, each one of which is concerned in safeguarding London, so that in the end we enjoy the glory of achievement and even borrow something of the glamour of the exquisitely pure origin of all water supplies. . . . . The passing years have intensified the writer's feelings of responsibility as adviser on the quality of London's water supply; his pen is still the champion of purity, and if it is used sometimes to embellish and lend colour to the subject of water supply, this is only because he believes that a quickening of interest is one of the surest ways to create and maintain a feeling of true responsibility.

The report is divided into eleven sections including details of chlorination, pre-filtration waters, double filtration, resistance to filtration and microscopical appearances of pre-filtration waters, meteorological notes, bacteriological researches and miscellaneous matter.

Pre-chlorination of the River Thames water, which was commenced in 1916 as an economic and emergency measure to assist the nation during a period of profound difficulty, has successfully passed its twelfth year. Prior to 1916 the River Thames supply was extracted from the River at Staines, and passed through the hugh storage reservoirs for sedimentation and purification. Observations have shown that excepting during flood periods, greater purification has been effected by pre-chlorination than was attained by prolonged storage. Approximately 76 million gallons have been treated daily without a single complaint of taste in a twelve year period. The combined Staines and Hampton (R. Thames) supplies during 1927 showed 66.8 per cent of all raw water samples gave negative B. coli tests in 100 cubic centimetres of water examined. Bearing in mind the initial pollution of the raw water, the bacteriological results are truly remarkable. The average dose of applied chlorine was 0.46 part per million, costing 21 cents per million gallons of water treated

and showed a net saving due to reduced pumpage costs in excess of $34,000. Pre-chlorination of Thames water is practised between flood periods whereas the treatment of the New River supply is carried out as a safety measure during floods. Chlorine was applied to the New River supply on 178 days and anti-taste reagents consisting of ammonium sulfate and potassium permanganate were applied on 174 and 4 days respectively at a total cost of 47.5 cents per million gallons.

In dealing with pre-filtration water an important note is sounded. The report says in part:

> The idea underlying the examination of pre-filtration waters, is that, if these can be pronounced to be epidemiologically safe, the perfect working of the filtration process becomes almost of secondary importance, except from the point of view of producing a physically attractive product.

Double filtration at the Barn Elms filters involving primary rapid sand and slow filtration, has enabled the slow sand filters to be increased to three times the normal rate. The conclusions arrived at after 40 months experience were:

1. A final product practically as good, on the average, as that resulting from ordinary slow sand filtration process.

2. Comparative freedom from algal troubles, or those caused by an excess of suspended matters, owing to the useful work carried out by the primary filters.

3. A much greater output of water per acre of filtration area, allowing for the space covered by the primary rapid filters per unit of time.

The treatment of R. Thames water at Walton consists of storage, primary and secondary filtration at a rate of 119.7 and 5.1 gallons per square foot per hour respectively (equivalent to 124.72 and 5.31 million imperial gallons per acre per day) followed by chlorination at the rate of 0.26 part per million. This treatment was found to produce a highly purified effluent. The primary or rapid sand filters averaged 40.5 hours per run with a maximum of 737 and a minimum of 1.5 hours. Secondary filtration through slow sand units gave an average of 445 million gallons per acre cleaned. The percentage of wash water in the rapid sand filters averaged 0.636 with a maximum of 2.37.

Laboratory observations dealing with resistance to filtration and microscopical appearances of pre-filtration waters, are probably the most unique on record. Permanent records of the suspended matter,

both qualitative and quantitative are daily made by means of photographs. By these means a complete picture is always available covering the microscopical and physical content of the water during the different stages of purification.

Extensive meteorological notes covering all parts of the world are included. The rainfall for the City of London during 1927 was 33.84 inches, an excess of 9.37 inches above the mean figures. The heavy floods experienced during parts of the year caused an unusual amount of color in some of the London waters.

Sections eight and nine of the report deal with bacteriological studies and include much valuable information. In discussing non-sporing aerobic lactose-negative microbes, attention is directed to the usual practice of selecting typical colonies for subculture. The following paragraph is of interest:

> In view of this practice of deliberately choosing the red colonies for study, we do not know as much perhaps as we should of the attributes of the colourless ones. Yet, the moment a water is under suspicion of having given rise to disease they become of paramount importance, and we are then faced with the difficulty that enough is not known of the colourless colonies occurring in water which is not giving rise to disease. In other words, we are not in the best position to study the colourless colonies in a suspected water, if we do not know all about the colourless colonies occurring in waters which are either entirely blameless, or, at all events, not apparently giving rise to disease.

Included in this category are the following: Typhoid group. Salmonella group of food-poisoning. Food poisoning group which, unlike the Salmonella, do not ferment dulcite, and the Dysentery groups of both Shiga and Flexner. The laboratory studies showed that 687 colourless colonies were subcultured from 1392 samples of water. The report states:

> The results show, on a comprehensive basis, that with waters not, so far as known, giving rise to disease, there are apparently no microbes occurring on the "rebipelagar slopes," (modified MacConkeys medium), made from the primary lactose bile-salt peptone media, liable to be mistaken for the bacteria belonging to the food-poisoning group, typhoid or dysentery groups, as defined by the writer. Unfortunately, it cannot be added that with water giving rise to disease these pathogenic bacteria would necesarily be isolated from them, because unless the microbes concerned are present in considerable number, their isolation is a matter of the greatest difficulty. Bacteriologists are still looking for a really reliable medium, which will enrich the growth of pathogenic bacteria and inhibit the growth of all other microbes.

The section devoted to the search for pathogenic microbes in water includes some outspoken comment on methods used for the isolation of the typhoid bacillus. The text includes the following:

The writer has pointed out long years ago that the value of these selective enrichment processes is frequently judged on erroneous assumption. It is not uncommon to add a very large number of typhoid bacilli to a water, and then, should success be subsequently achieved in their isolation, it is claimed that under the particular conditions of the specific contamination of an actual water supply similar results would be achieved. The writer thinks that the fallacious conclusion has sometimes been drawn that because a particular medium has been found to be successful in the case of feces, it necessarily must be of equal, or greater, value in the examination of sewages and waters. In the case of sewage and many waters we often have present, in preponderating numbers, highly resistant coli-like and other microbes which grow, and grow well, in doses of inhibitory agents that are either fatal to the typhoid bacillus, or markedly inimical. It does not, therefore, follow that a method successful in the case of feces will be equally, if at all, suitable for the examination of other materials.

Exhaustive figures are given showing attempts at recovery of the paratyphoid bacillus artifically added to filtered and mixed raw and filtered water. In these experiments no inhibitory reagents were used in the media excepting 1 per cent of bile-salt. Very small numbers of the bacilli were added to the water, the maximum figure being 3 per 10 cubic centimeters and the minimum 0.083. Out of 57 inoculations, recovery was made in 49 samples. Brief mention is made of the work of Wilson and Blair using a glucose bismuth iron medium for the isolation of the typhoid bacillus and encouraging results are expected.

The miscellaneous section deals chiefly with green growth in New River water, leptospira in water, typhoid fever, excess lime treatment and the question of accident. The green growths in the New River supply are described as of a protococcus-like nature. On two of the works the green cells passed slow sand filters and the water as delivered to consumers was green in color. Copper sulfate experiments carried out in the laboratory indicated that doses up to 2 in 1 million, had little or no effect in removing the trouble. Chlorine in doses of 1 in 1 million had a bleaching if not destructive effect. As a result, the water was chlorinated and aerated and the trouble corrected in a short period. Sir Alexander Houston believes that copper sulfate, at all events in reasonable doses, is of little or no value as a preventive

measure in the case of certain green algae. Its value was however demonstrated in destroying various forms of diatoms.

Search for leptospira in water was carried out during the year and in certain supplies was recovered prior to chlorination but was not found after chlorination. The pathogenicity of all positive cultures was tested and all results were negative. Emphasis is laid on the increasing practice of using water in swimming pools over and over again, after some form of filtration. Chlorination in this connection is absolutely essential as filtration would not remove leptospiral organisms whereas chlorine would effectively destroy them.

Success of the excess lime method for softening and sterilising is reported at an English city where a hard polluted water was the source of supply.

An extensive addendum which includes a large number of tabulated laboratory records, hydraulic equivalents and conversions completes the supply. The statistics show that London has 49 storage reservoirs covering 2704.5 acres holding 19,657 million gallons, 92 service reservoirs holding 321.1 millions, 178 filter beds covering 175.7 acres, 271 engines of 47,251 h.p., 6970 miles of water mains. The average daily consumption is 260 million imperial gallons, supplying a population in excess of 7 millions, equivalent to 36 imperial gallons per capita.

Time and space does not permit of justice being done in this brief review of Sir Alexander Houston's report. To those desirous of keeping apace with the times the report of the London Water Board Laboratories is an absolute necessity.

CHLORINATION OF DEEP WELL SUPPLY FOR TASTE AND ODOR REMOVAL[1]

By M. F. Trice[2]

In the early summer of 1928 a disagreeable taste and odor developed in the Siler City water supply. At that time the municipal water system had been in operation three years. There had been no objection to the city water during the first year, but during the second, in the spring of 1927, a taste and slight odor developed which was easily detected. This condition existed for some two months, disappearing before the end of the summer; the one remedy applied at the time was periodic flushing of the mains. No trouble has been experienced during the winter months. With the advent of spring, however, the taste and odor returned with greater intensity, reaching a maximum last May. The citizens refused to use the city water preferring well and spring supplies. Flushing of mains was resorted to, but with little success. Samples of water sent into the State Laboratory for examination were found to be of satisfactory sanitary quality. This fact was broadcast, but to no avail, and complaints were daily piling into the city clerk's office. This was the status of the problem when an investigation was begun to locate and, if possible, to eliminate the offending taste and odor.

The present municipal supply was constructed and installed during the summer of 1925 and was put into service in September of that year. Briefly the system consists of two deep wells, 365 and 380 feet deep respectively. A separate pump serves each and both discharge into a covered concrete reservoir of 200,000 gallon capacity. As an additional reserve a steel elevated tank of 100,000 gallon capacity is available. All equipment, mains, service connections, etc., were new except one pump bought second hand.

The fact that the entire system was of new material made pipe growths appear an unlikely hypothesis. Contamination from an open trap door in reservoir or elevated tank or possible diffusion of

[1] Presented before the North Carolina Section meeting, November 20, 1928.

[2] Assistant Engineer, State Board of Health, Raleigh, N. C.

mill sprinkler water into the city mains received more serious consideration as an explanation. Investigation disclosed that the trap doors to the reservoir and elevated tank, respectively, were always closed.

A textile mill, operating a sprinkler system using city water, was connected through check valves and several other industrial establishments using air filled sprinkler systems were found to maintain a constant air pressure greater than the water pressure. The air systems, too, were connected to the city system through a complicated arrangement of valves. The various mill sprinkler systems have been installed since the town supply was inaugurated, except the textile mill whose sprinkler system antedates the establishment of the town supply. Some doubt existed as to whether or not the latter should be eliminated as the source of trouble. It was eliminated for the time being as were the other industrial establishments and attention directed to the mineral and biological character of the water.

Ground water supplies of the state differ from the surface supplies in that practically all are hard waters and contain an appreciable and sometimes objectionable quantity of iron. The Siler City water was characteristic of all such supplies, the iron content being noticeable as indicated by housewives complaining of a brown sediment forming in kettles and pots. Field equipment did not contain reagents for an iron determination. Results of a few simple tests are as follows: pH 7.2; hardness (soap method) 81 p.p.m. and alkalinity to methyl orange 103 p.p.m.

It was observed on several occasions that in flushing mains the water flowing for the first few minutes contained a brown sediment. Every water superintendent is familiar with such occurrences and expect such to happen in sections of town where little water is used. It is often the case that water acquires a flat taste and sometimes an odor due to stagnation in a pipe line that serves few houses. This condition is immediately relieved by a thorough flushing of the mains. A great many taste and odor problems are relieved by this simple expedient. At Siler City the taste and odor persisted in spite of thorough and frequent flushings. Evidently then some pipe condition was to blame.

Samples of water from the hydrants containing this brown sediment were therefore examined microscopically for the presence of iron bacteria, as crenothrix was suspected. In several samples examined small thread-like filaments were observed. This seemed to

be sufficiently conclusive that iron bacteria existed in the distribution system. As flushing had not removed the taste and odor problem, it was decided to sterilize the mains with chlorine.

Accordingly, an emergency chlorinator outfit was brought from Raleigh and a tank of chlorine obtained. As a heavy application of chlorine seemed advisable, it was deemed unwise to chlorinate during the day. Therefore, to inconvenience the citizens as little as possible, the chlorination was begun at eleven o'clock at night.

The chlorinator is a dry feed apparatus of the diffuser type. It was attached to the effluent from the reservoir at a point half way between that and the pump to town. With a hydrant open in town, pumping was started with strong chlorine application. A hydrant was allowed to run until a good orthotolidine test was obtained, when another hydrant was opened and the process repeated. Thus hydrants were flushed in all parts of town until the entire system was saturated with chlorine. This required about five hours, as chlorination was complete at 4:00 a.m. the following morning.

The next day the town office received many complaints, as the chlorine content of the water was sufficient to be objectionable. With the disappearance of the chlorine from the system, the taste and odor situation improved and within a week all trace of it was gone. The superintendent is positive that flushing alone would not have completely remedied the trouble, and provided that it would have been effective, the cost would have been much greater.

This is the first instance of its kind in North Carolina where iron bacteria have been satisfactorily eliminated from a distribution system with chlorine.

CHLORINATION OF COAGULATED WATER[1]

By J. S. Whitener[2]

Results obtained by chlorination of coagulated water at the Raleigh, N. C. filtration plant for the year of September 1, 1927 to September 1, 1928 as compared to the previous year of September 1, 1926 to September 1, 1927 without chlorination are given in table 1. These results were made possible by the fact that E. B. Bain, who has been superintendent of water works at Raleigh for thirty years, has kept a very complete set of records. Credit is also given to J. J. Vereen who succeeded the writer at the Raleigh plant and continued the chlorination of coagulated water.

Attention is called to the results which it is believed were directly obtained by prechlorination. These are increased in length of filter runs; decrease in percentage of wash water; increase in gallons of water filtered per filter washing; decrease in total bacterial count of coagulated, filtered and disinfected water, notwithstanding the fact that the total count on raw water for the year of prechlorination was much higher than the year before; decrease in the B. coli index of filtered and chlorinated water, although the raw water B. coli index for the year of prechlorination was much higher.

To analyze the above results is a somewhat difficult task due to the fact that there was a decrease in plant output, a difference in raw water turbidity, an increase in wash water per filter washing and an increased cost of wash water.

The decrease in plant output was caused by a decrease in consumption. A metering program was in the process of being carried out and at the present time the city is 96 per cent metered.

The difference in raw water turbidity was caused by the fact that the year of prechlorination was a wet year and the year before was a dry one.

The increase in wash water was caused by the increased raw water turbidity.

[1] Presented before the North Carolina Section meeting, November 20, 1928.

[2] Assistant Engineer, State Board of Health, Raleigh, N. C.

TABLE 1

Operating data, Raleigh, N. C., 1926–27 and 1927–28

	1926–27	1927–28
Gallons of water treated	1,148,557,000	1,074,523,000
Daily average gallons water treated	3,146,000	2,933,000
Filter yield, m.g.a.d.	64.5	57.15
Rate of filtration	94.8	86.4
Hours plant was operated daily	17.9	16.66
Filter runs, average hours	26.75	39.57
Per cent wash water	3.96	3.33
Total number filters washed	2,484	1,810
Total gallons wash water used	46,214,000	36,768,000
Number gallons used per filter washing	18,600	20,300
Cost of wash water, dollars	2,505.56	2,032.72
Cost of wash water per filter washed, dollars	1.009	1.123
Gallons water filtered per filter washing	462,378	593,625
Total pounds chlorine used	3,723	5.170
Cost of chlorine, dollars	368.58	511.83
Chemical dosage:		
Alum, g.p.g.	1.02	1.17
Lime, g.p.g.	0.028	0.033
Chlorine, p.p.m.	0.39	coag. 0.35 filt. 0.244
Raw water turbidity, p.p.m.	43	95
Coagulated water turbidity, p.p.m	4.1	3.3
Total bacteria per cubic centimeter, raw water	174	275
Total bacteria per cubic centimeter, coagulated water	41	29
Total bacteria per cubic centimeter, filtered water	24.6	19.5
Total bacteria per cubic centimeter, disinfected water	0.6	0.37
B. coli index per 100 cc., raw	336	507
B. coli index per 100 cc., filtered	10.49	3.73
B. coli index per 100 cc., disinfected	0.064	0.00

The increased cost of wash water was caused by the decrease in plant output which with the same plant overhead increased the cost per million gallons.

In arriving at the saving in dollars and cents the gallons of water filtered per filter washing (462,378) for the previous year was divided into the total plant output for the year of prechlorination (1,074,523,000). This gave 2324 as the theoretical number of filter washings. Subtracting from this the actual number of filter washings gave a saving of 514 filter washings at $1.123 or $577.22. From this was subtracted the increased cost of chlorine ($143.75) leaving a net saving of $433.47. Taking the average plant output for the two years as 3 million gallons per day, a saving of $144.49 per million gallons of plant output per year was effected.

Prior to prechlorination the filters were in pretty bad condition. At the end of a run the mat would be cracked in several places near the middle of the filter and would pull away from the side walls. Hard spots would develop down in the sand and had to be broken up with a pole every time the filter was washed. This trouble has now entirely disappeared and the filter presents a smooth unbroken surface at all times with no hard spots in the sand.

Enough chlorine was applied to the coagulated water to give a residual of 0.2 p.p.m. and at no time did the filter effluent show residual chlorine. Just why the application of chlorine gave these results is still unknown, but it is thought that the chlorine kills the organisms that cause contraction of the mat and those that furnish the cementing material to the sand grains, causing hard spots.

The fact that all hard spots have disappeared and the filters now present a smooth unbroken mat, accounts for the greater bacterial removal, as shown in table 1, and for the clear sparkling effluent from the filters at all times. The clear water reservoirs still become slightly cloudy at times, but this has been traced directly to the secondary lime which is added between the filters and the clear water reservoirs.

PRECHLORINATION AT SOUTHERN PINES, N. C.

This plant handles a colored water in which there is at no time any clay present.

Chlorination of the coagulated water was tried with no beneficial results, but when chlorine was added to the raw water in the mixing chamber along with the alum and lime, some surprising results were

noted. With the same dosage of alum and lime the size and density of the floc were practically doubled. This, as any one knows who works with colored water, is very desirable and in this case caused a very much greater color removal in the coagulation basin. The filter runs were increased from nine to twenty-five hours, and the filter effluent was better than it ever had been before. Cracks and hard spots in the center of the filter were not eliminated, but it is known that they are caused by a "dead" manifold, that is, a manifold which has no perforation or strainer cups. This means that no wash water passes up through the sand over the manifold and this sand area is useless.

The above experiment is very recent, having been going on about a month. The results so far were so surprising it was felt that something should be said about them. It may be added that no iron has yet been found in the raw water, but additional tests will be run and the complete results of this experiment will be available at a later date.

COPPER AND THE HUMAN ORGANISM[1]

That the quantities of copper found in food and drinking water will not injure any human organ, is the conclusion reached after nearly three years of experimentation and research work which has just been completed by Dr. Frederick B. Flinn and Dr. William C. von Glahn of Columbia University. The results are published in the current issue of the Journal of Experimental Medicine, a publication issued by the Rockefeller Institute. The work done by Drs. Flinn and von Glahn was under the general supervision of Dr. James W. Jobling, Professor of Pathology at Columbia University and President of The American Association of Pathologists and Bacteriologists.

The findings are of unusual interest to the medical profession because they refute the theory that copper is the etiological agent of the human disease, hemocromatosis, which was advanced several years ago by Dr. Mallory, the eminent pathologist of the Boston City Hospital.[2]

The question as to whether or not the amounts of copper found in our food and drinking water have any ill effects on the human organs, causing chronic diseases, is important to the average household, because of the increasing use of copper and its alloys in our homes.

Early investigators have not been uniform in their opinions, but the weight of evidence was that copper was not a harmful substance in the amounts that occured in our food and drinking water.

Mallory, a pathologist who has been interested for some time in the subject of cirrhosis of the liver, came to the conclusion that copper might be the underlying cause of the comparatively rare disease known as hemochromatosis which has generally been found among men of middle age. He arrived at this conclusion from the fact that there seemed, at the time he made his observation, a sudden increase in the number of cases showing this pathologic lesion on autopsy.

[1] Summary of an article in The Journal of Experimental Medicine, published by the Rockefeller Institute, January 1, 1929. Reported here because of its importance in connection with the use of copper services and pipe.—*Editor*.

[2] The Poisonous Effects of Copper. F. B. Mallory. Jour. N. E. W. W. A., March, 1927, p. 27.—*Editor*.

As a general thing a history of the cases revealed the fact they had been accustomed to drinking alcoholic beverages sold since prohibition came into effect. An analysis of many samples of bootleg liquors sold in the city of Boston revealed the presence of copper in larger amounts than had been suspected and it was felt that it had been dissolved from the copper coils during distilling of the crude liquors.

About the time these cases appeared in the Boston City Hospital similar increases in cases in other hospitals in different cities were noted, but the number soon dropped down to the normal level, at which one or two cases occur a year. This disease is comparatively rare and Mallory only reports twenty cases.

In an attempt to show that the pigmentation of the liver associated with hemocromatosis was due to copper, rabbits were fed copper acetate for months and, after an examination of the liver, he came to the conclusion that "chronic poisoning with the salts of copper produced in the livers of rabbits in six months to a year, a change comparable in many ways with those found in the liver in a chronic disease in man known as 'hemochromatosis.'" He felt justified, therefore, in saying that chronic copper poisoning apparently was the causative agent of this disease in man.

This finding was so contrary to the general consensus of investigators that the Departments of Industrial Hygiene and Pathology of Columbia University undertook jointly a careful investigation of the whole question of the effects of copper on the human system. Their findings seem to indicate that the conclusions Mallory had drawn from his rabbits might have been founded on a wrong hypothesis.

Flinn and von Glahn examined twenty specimens of human livers obtained from routine necropsies, in addition to other specimens obtained from copper workers. It was found that the copper contents of these livers varied from 2.40 to 12.42 mgm. per kilogram of tissue, and what seems particularly interesting the copper contents of the livers of these copper workers were close to the minimum. Livers of numerous animals were examined and all found to contain copper—the amounts varying with the species. It is known that copper is always present in human milk as is also the case with cow's milk. Practically all vegetables contain this metal. It is found in most insects and many marine animals. It takes the place of iron

in the blood of lobsters and crabs. In other words copper is universally found in all plant and animal life.

Von Glahn and Flinn made an investigation with scientific controls, to determine, if possible, whether feeding copper or its compounds to animals was responsible for the pigmentation of the liver. Rabbits, rats and guinea pigs were used in their research, and definite amounts of the metal fed so that the exact exposure of the animal was known at all times. In this way it was shown by an analysis of the body when the animal was killed or died that practically all of the metal is eliminated. An examination of the various organs showed that, while they might contain very small quantities of the metal, the liver was the main storage place of copper retained in the body. Work reported by Flinn and Inouye shows that almost all of the copper ingested by the animal is eliminated in the stools.

The investigators at Columbia University Medical School recognized in planning their research that the control rabbit which had no exposure often showed the same lesions that one found in the exposed animal, and for this reason one is apt to draw wrong conclusions. They took particular care, therefore, to examine normal rabbits kept under exactly the same condition as to food and environment as the exposed animal. The only difference being that they were not fed copper.

The rabbits were divided into groups and fed different salts of copper as well as varying amounts. The animals were fed on what was called a standard diet, consisting of unrestricted quantities of hay and oats, with carrots and cabbage on alternate days. It seemed of interest to determine whether the acid radicle in the copper salts were of importance in influencing the deposition of the pigment. With this in view rabbits were given 100 mgm. of sodium acetate daily in chopped cabbage, along with their regular diet.

The result of the sodium acetate experiment raised the question of possible occurrence of pigment in the liver cells without the intervention of the metal and one naturally turned to the diet. An examination of the standard diet suggested carrots as the most probable source of the pigment.

A number of rabbits were operated on and a piece of the liver removed for histological examination. Pigmentation and similar conditions were found in the livers of these unexposed animals similar to those noticed in the copper and sodium acetate fed rabbits.

A number of the rabbits from which a specimen of liver had been removed were kept on a strict carrot diet. An examination of the animals showed an increase in the amount of pigment for 4 weeks, but after that did not increase even if the animal were kept on carrots exclusively for 19 weeks. However, it greatly exceeded in amount that which existed in the liver of any control animal.

Animals kept exclusively on carrots were fed copper also to see if a combination of copper with a carrot diet would produce even greater deposits. The pigment in the liver was definitely increased, but no difference could be detected in the amount of connective tissue in the portal area.

Similar experiments, conducted with white and yellow turnips, showed that, compared with that present in the liver removed before the special diet was begun, the pigment was increased. This increase was not striking on either of the turnip diets—it did not exceed that found in the liver of the rabbit fed on carrots alone for one week, and was not nearly so abundant as in the livers of rabbits fed on carrots for two weeks or longer.

All of the experiments carried out by these investigators made it apparent that copper is not the cause of the pigment deposit in the liver of the rabbit, since the same change is produced when sodium acetate is given with the standard diet. Furthermore, when rabbits are fed on a diet of carrots exclusively, the deposition of pigment occurs with greater rapidity than with copper or its compounds and the standard diet. The changes resulting in the livers of carrot fed animals are identical in every way with those seen following doses of copper, and in animals given comparable doses of sodium acetate. On a diet of peeled turnips, pigment is deposited in the liver of the rabbit, though more slowly than with carrots.

In none of the rabbits given copper could a definite cirrhosis be proven. It is true that in some of the portal areas there appeared to be a slight increase in the number of connective tissue cells. This also was readily made out in the sodium acetate animals and in those on a diet of carrots. The increased connective tissue was so slight that one would hesitate to make a diagnosis of cirrhosis. Even if it might, in the opinion of some, be considered a cirrhosis, its occurrence in the livers of the animals given sodium acetate as well as in those on a diet of carrots, would exclude copper as the etiological factor. Regarding the nature of the pigment, nothing definite can be

said at the present time. Concerning its source the evidence indicates that it is of exogenous origin, for it is found in such great abundance in rabbits fed upon carrots only, and in lesser amounts in those on a diet of turnips.

The conclusions of the workers at Columbia University are:

That copper or its compounds used does not cause the deposition of pigment in the liver of rabbits, guinea pigs or rats. Neither does it produce a cirrhosis in these animals.

That spontaneous deposition of pigment occurs frequently in the livers of normal rabbits on the usual laboratory diet.

That the feeding of a diet of carrots exclusively will produce pigment deposition in the livers of rabbits in every way identical with that ascribed to copper.

That the pigment deposited in the livers of rabbits is probably of exogenous origin.

With these conclusions proven by the carefully controlled work of Flinn and von Glahn the theory of Mallory that copper is the etiological agent of the human disease "hemochromatosis" is shown to be founded on a wrong hypothesis, for he bases his theory on observations on pigmentation in the livers of animals. This pigment has now been shown to be due to exogenous origin.

As the evidence now exists the quantities of copper that are found in our food and drinking water will not injure any human organ. In fact, evidence is accumulating showing that small amounts have a beneficial effect on the blood in cases of anemia.

SOCIETY AFFAIRS

NORTH CAROLINA SECTION

The eighth annual convention of the North Carolina Section and the sixth annual Conference on Water Purification and Sewage Treatment were held at the Sir Walter Hotel, Raleigh, on November 19, 20 and 21, 1928. The tradition of enthusiasm in the Section's meetirgs was upheld. The program was good, and the discussions and interest were live. Representatives were present from 15 states of the South, East and Middle West, and the registration reached 269, a new record. Of this number, 177 were men actually engaged in the design, construction, operation and management of water supply and sewage disposal works, 67 were commercial representatives of manufactures and dealers, and 25 were visitors. About 25 exhibits were attractively arranged on the mezzanine floor of the Sir Walter, which evoked the greatest interest.

President C. G. Logan of Waynesville presided at the general sessions, while Chairman J. S. Whitener had charge of the meetings of the Conference on Water Purification and Sewage Treatment. The Section was honored by the presence of Mr. Beekman C. Little, Secretary, and Mr. J. O. Craig, Director, of the parent Association, who brought greetings and good wishes from the national organization.

Following registration on the morning of the opening day, the following papers were given:

"Advantages and Economics of Elevated Storage," by C. W. Smedberg.

"Two-Main System of Water Distribution," by W. E. Vest.

"Water Resources Investigations in North Carolina," by Thorndike Saville.

On the afternoon of the first day the following program was presented:

"Advantages of Detailed Cost Data on Water Purification," by J. M. Jarrett.

"Some Notes on Present-Day Sewage Disposal Processes and Problems," by Wm. M. Piatt.

Report of Statistics Committee, by Stanley H. Wright.

On Monday evening the City of Raleigh was host to the convention at a sumptuous dinner given at the Hotel Sir Walter, which was enjoyed by 275 members, guests and city officials. Mr. E. B. Bain, genial superintendent of water works, presided as toastmaster and introduced Hon. E. E. Culbreth, Mayor of Raleigh, who welcomed the Section to the Capitol City. President C. G. Logan responded on behalf of the Association.

On Tuesday morning, November 20, the Conference on Water Purification and Sewage Treatment held a symposium on the use of chlorine in water treatment, with the following papers and discussions:

"Coagulation Studies with Chlorinated Copperas," by L. L. Hedgepeth.

"Results Obtained by Chlorination of Coagulated Water,"[1] by J. S. Whitener.

"Chlorination of Deep Well Supply for Taste and Odor Removal,"[2] by M. F. Trice.

"The Importance of Keeping a Filter Plant Clean," by E. H. Moss.

On the afternoon of the second day a question-box session was held, devoted entirely to the discussion of topics suggested by the members. The following subjects were considered:

"Water Rates,—Scales in Use and Discounts Allowed."

"Meteorological Data Collected by Municipalities."

"Operating Procedure for Hydro-Electric Plant as Part of Water Supply Project."

"Watershed Forestry Practice."

"Most Practical Way of Cleaning Filters Without Removing Sand Beds."

"How to Keep Water Works Employees out of Politics."

"Circulation in Water Mains."

"Water Waste Surveys."

"Algae Control in Settling Basins."

"Fire Sprinkling Service Lines."

"Practice in Painting Standpipes and Elevated Tanks."

The question-box session was one of the most live and interesting

[1] This Journal, page 258.
[2] This Journal, page 255

of the convention. It was the sentiment of the meeting that such a symposium be held in the future, since it provides for the amplification of the regular limited programs by giving an opportunity to the membership of presenting their practical problems for discussion.

On Tuesday evening, November 20, the annual Association banquet was held at the Sir Walter, with President Logan presiding as toastmaster. Two hundred members and guests were in attendance. Following the dinner Dr. John D. Rue, Director of Research of the Champion Fibre Co., Canton, N. C., delivered an interesting paper on the subject, "Disposal of Industrial Wastes." He described the processes employed in pulp and paper manufacture, the immense quantities of water used, the waste recovery processes that have been economically developed, and the quantities and characteristics of the wastes which are discharged. He treated the subject from the standpoint of the value of coöperation between industries manufacturing related products, between those manufacturing unrelated products, and between industries and the state. Major Wade H. Phillips, Director of the Department of Conservation and Development, discussed the importance to water works men of the water resources investigations which that organization is carrying on, and emphasized the need for increased appropriation to permit the expansion of the work. Secretary Beekman C. Little and Past President James E. Gibson of the National Association discussed the work and program of the parent organization and the relationship of the local sections to the Association. President-elect McKean Maffitt, in a spirited inaugural address, set forth the growth and accomplishments of the North Carolina Section during its eight years of existence, and outlined the objectives of the future.

The program on Wednesday morning, November 21, was devoted to sewage treatment topics. The following very interesting papers were given, each of which drew lengthy discussion:

"Preliminary Operating Results of the Charlotte Activated Sludge Plants," by E. G. McConnell.

"Separate Sludge Digestion Studies," by Anthony J. Fischer.

"Experimental Studies on the Treatment of Combined Sewage and Textile Wastes," by Albert M. Worth.

"Biochemical Oxygen Demand Reduction by Chlorination," by H. G. Baity and F. M. Bell.

The annual business meeting was held on Monday night, following the complimentary dinner. Reports of the officers of the Section

were heard and approved, as were the reports of the several standing and special committees. The most important item of business was the consideration of the recent ruling of the Water Works Manufacturers Association prohibiting its member firms exhibiting at local section meetings. During the discussions on this mattter all of the manufacturers' representatives present were invited to sit in the meeting. All of the correspondence with the Manufacturers Association protesting against the discontinuance of exhibits was read by the secretary, and was unanimously approved. After hearing from several members of the Section, officers of the parent Association, and the manufacturers' representatives, all of whom expressed regret at the action of the Manufacturers' Association, the meeting went on record with resolutions asking for a reconsideration of the matter by the manufacturers, and permission for their member firms to continue to place exhibits at North Carolina Section meetings. The exhibits have always been one of the most attractive and valuable features of the Section's meetings. No charge is made for exhibit space or privilege; no funds have been sought by the Section for carrying on its business or entertainment of its conventions; and the sentiment of the membership is distinctly against the acceptance in the future of entertainment or any direct or indirect contribution for any purpose from the commercial men participating in the annual meetings.

With the feeling that the general interest in the technical phases of water supply and purification made it no longer necessary to continue a sub-organization for the discussion of such problems, the Conference on Water Purification and Sewage Treatment was abolished. It was recommended that a separate organization, to be known as the North Carolina Sewage Works Association, be established, which would hold its annual meetings jointly with the North Carolina Section, A. W. W. A.; handle all matters pertaining to sewerage, sewage treatment and stream sanitation, and become the local organization participating in the national Federation of Sewage Works Associations.

High Point was chosen as the 1929 convention city, with headquarters at the Sheraton Hotel, and the date was fixed as November 4, 5 and 6.

The following officers were elected for the ensuing year: President, McKean Maffitt, Wilmington; Vice-President, P. J. Dishner, High

Point; Secretary-Treasurer, H. G. Baity, Chapel Hill; Editor, E. G. McConnell, Charlotte.

Resolutions were adopted expressing the gratitude of the Section to the City of Raleigh and its officials for their hospitality and entertainment, to the many out-of-state visitors for their splendid contributions to the program, to the manufacturers whose interest and coöperation have assisted so materially in the success of the conventions, and to the press representatives whose publicity carried to the people of the State an interpretation of the vital enterprises in which the Section is engaged.

H. G. Baity,
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Proceedings of Tenth Texas Water Works Short School, January 23-27, 1928. Part 1, Water; Part 2, Sewage. Part 1. Constitution of the Southwest Water Works Association Proposed October 12, 1927, and Adopted as Amended October 12, 1927. Hot Springs, Arkansas, 26. **Status of Water Supplies in Texas—Our State Program.** DR. J. C. ANDERSON. 32. **Accomplishment of the Oklahoma Water Works School.** O. M. SMITH, 34. **Engineering Progress in the Middle West.** WYNKOOP KIERSTED, 37. The value of gumbo in waterproofing is illustrated in the case of the dam at Council Bluffs, Iowa, where in 1883 gumbo was used to line the reservoir. It stood the test for twenty-five years and is thought to be still doing service. Writer believes most notable improvement in water purification is in sedimentation and sterilization. **Design Data for Well Supplies.** JULIAN MONTGOMERY, 41. **Design Data for Well Supplies.** D. H. HUNTER, 45. **Design Data for Distribution Systems.** T. W. HANLON, 46. **Design Data for Rapid Sand Filter.** E. W. BACHARACH and A. W. LIVINGSTON, 49. In order that the superintendent, city official, or filter operator may know some of the problems that the consulting engineer has to consider, the general features of design of a rapid sand filter are briefly described. **Dosing Apparatus.** WYNKOOP KIERSTED, 54. **Factors Considered in the Design of the Abilene, Texas, Water Purification Plant.** O. K. HOBBS, 57. Lake Abilene, located nineteen miles southwest of the city of Abilene, furnished that town with a water supply delivered by gravity through 18 inch cast iron mains to two 20 million gallon storage basins. A 4 m.g.d. treatment plant has been designed to include special methods of proportioning the chemical dosage. Specially designed chemical control machines have been installed, operating under principle of the under-shot water wheel placed in a channel carrying water to the treatment plant—this wheel acting as a positive displacement of meter and furnishing power to drive the machines which mechanically measure out the lime slurry and the iron solution used in the softening and coagulation of the raw water. Special types of mixers and weirs have been included in the design and are very creditably discussed in this paper. **Items to Consider in Selecting a Water Supply Source.** JAS. D. FOWLER, 61. The major items to be considered are listed and discussed in the following order of importance: Adequacy; Sanitation; Desirability and Cost.

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Sanitary Defects of Water Supplies and Distribution Systems. J. L. BARRON, 65. The general purpose of the article is to point out some ways of accounting for the contamination of municipal water supplies. Elimination of such contamination is a problem of the engineer in location and design and of the water superintendent in maintenance and operation. **Current Practice in Laying Water Mains, House Laterals and Repairing Leaks.** LEWIS A. QUIGLEY, 71. **Paint Preservative Specifications for Metal Tanks.** C. M. BARDWELL, 74. Laboratory and field tests to find a suitable protective coating for interior of steel water storage tanks, indicate: linseed oil base paints to be unsatisfactory; some asphaltic base paints satisfactory but high in cost; coating of cement grout found satisfactory when properly applied. **Filter Plant Troubles.** C. ARTHUR BROWN, 77. The author lists a number of major difficulties due to design, among which he includes failure to provide a measurement of flow into the plant, lack of grit chambers, inefficient mixing chambers, inadequate size of tortuous passage ways between mixing chamber and settling basin, split flows and improper introduction of treated water in the settling basins. The author believes the theoretical uniform rate of rise through the entire area of the sand bed to be wrong in principle, and suggests a possible elimination of the gravel layer. **Filter Plant Loadings.** H. W. STREETER, 85. This article notes briefly the result of studies by the United States Public Health Service, to determine by observation and experiment the kind and percentage removal of organisms. The studies indicate that the efficiency of each separate process involved in water purification is influenced by a number of factors. It was found that well designed and operated rapid-sand filtration plants treating waters such as are found in the Ohio and other river basins of the Middle Western plains are capable of producing, a final chlorinated effluent of accepted palatability and conforming to revised Treasury Department standard if the *B. coli* index of the raw water does not exceed approximately 5,000 per 100 cc. Along the Great Lakes, however, the average plants cannot meet the same standard if the *B. coli* index exceeds an amount falling below 2,000 per 100 cc. Some interesting data bearing on the relation between the cost of water purification and the average density of raw water pollution are included. **Recent Developments in Standards and Railway Equipment for Providing Certified Water in Interstate Commerce.** J. H. DAVIDSON, 89. **A New System of Fluid Measurement, Control, Indication, Integration and Recording.** C. ARTHUR BROWN, 98. Description of the magnetic clutch gulper meter for measuring small flows. Duplicate or triplicate records at two or three different points may be provided for. Records are exactly alike in time and volume of flow and cannot be tampered with or doctored by operators. **The Value of Plant Records.** HELMAN ROSENTHAL, 102. **The Waco Water Problem.** W. H. DEATON, 104. **The St. Louis Water Problem.** L. A. DAY, 105. Description of existing plant on the Mississippi River at the Chain of Rocks and new plant under construction on the Missouri River. Water will be taken from the river, flow through a travelling screen to low lift pumps which will deliver the water into two primary clarifiers. Water leaving the primary clarifiers will pass through primary rapid mixing conduit into two circular mixing tanks, then to secondary clarifiers, coagulating basins, carbon dioxide charging basin, secondary rapid mixing conduit, secondary coagulation basin and filters. The filter effluent will be chlorinated. **The Swimming Pools**

in the Houston Public Schools. T. O. Woolley, M.D., 111. **Some Old and New Factors in Water Softening.** Daniel H. Rupp, 115. **The Application of Hydrogen Ion Control to Water and Sewage Work.** W. A. Taylor, 117. The author devotes the greater part of this article to a detailed explanation of the meaning of hydrogen ion concentration and the methods by which it may be determined. The application of pH control to water purification, particularly in the matter of securing the optimum pH for the most economical coagulation of public water supplies is treated at some length. That the proper pH control is of great value in correction of "red water" and other problems due to corrosive action is brought out, as well as its applicability to water softening processes and with particular reference to boiler feed water, cooling water for condensers, and refrigerating brines. With relation to sewage disposal work, the investigations conducted by Dr. Rudolfs of New Jersey are made the basis of applicability of pH control to the most efficient sludge digestion methods, whether in Imhoff, septic, oı separate sludge digestion tanks. The author concludes his article with a discussion of the application of pH control to the problem of industrial waste treatment. **Adaptability of Sodium Aluminate in Water Treatment.** P. W. Evans, 135. **Progress in Chlorination.** Wm. J. Orchard, 142. Twenty years progress in chlorination is briefly summarized. The part played by chlorination in water treatment is stressed in emphasizing the fact that it is not a substitute for coagulation or filtration. Discussion by E. S. Tisdale. **Algae—Methods of Eliminating Tastes and Odors.** Chester Cohen, 146. The use of copper sulphate and chlorine in eliminating algae tastes and odors is described. Discussion by Buel Ruthven. **Economical Treatment of Swimming Pool Waters.** Lewis O. Bernhagen, 150. Herein are given briefly the principal standards of water quality for pools as formulated by the joint Committee on Swimming Pool Standards, followed by a discussion of the three general types of pools namely: the fill-and-draw, the flowing-through, and the recirculation pools. The author states that at Beaumont, Texas, water was supplied a flowing-through pool by a well at slightly less than five cents per 1,000 gallons, using air lift pumping equipment, air being supplied by a Gardner Duplex Compressor operated by a 20 h.p. motor with power cost of three cents per kilowatt hour. However, as most wells put down at a moderate cost cannot be depended upon for an unfailing supply, a hypothetical example of comparative costs for a 600,000 gallon pool is worked out, with itemized estimate of initial cost and operation of recirculation pool with filtration and disinfection, and operating cost of flowing-through pool. It is estimated that the former will give a 51 per cent return on the initial investment of $6,500 over that of the latter method. There follows a brief discussion by Paul S. Fox, bringing out the necessity of enforcement of soap and water cleansing of bathers prior to use of a pool, importance of water temperature not exceeding 72°F. and the advantages of chlorine compounds over ultra-violet ray disinfection. **The Microscopic Life in Water.** Asa C. Chandler, 155. **Elimination of Errors in the Ortho-Tolidine Method.** F. R. McCrumb, 160. A modified ortho-tolidine method based on the use of a comparator and standard color tubes similar to those used in the colorimetric determination of hydrogen ion concentrations, is described. **The Differentiation of Fecal from Non-Fecal Colon Bacteria.** I. M. Lewis, 168. **The Function**

of Aeration in Water Purification. N. Y. VEATCH, JR., 172. The efficiency of aeration in iron and manganese removal, odor removal, treatment for aggressiveness or corrosiveness, and as an aid to coagulation, is established, and like filtration or carbonation, aeration is a valuable tool, to be used in the proper place in the water-treatment plant.—*A. W. Blohm.*

The Bahrdt Method for the Volumetric Determination of Sulfate in Water. I. II. M. KEHREN and H. STOMMEL. Chem Ztg., 46: 913–5, 934–5, 1927. From Chem. Abst., 22: 654, February 20, 1928. This method requires 30 per cent too little sodium permutit and rate of filtration is 3 times too fast. In apparatus designed by authors, a large amount of permutit can be used, thus allowing several samples to be passed through without regeneration. They have also developed new permutit which is 3 times as efficient as ordinary permutit. Iron at concentrations higher than 1 p.p.m. causes low results. This can be overcome by first passing sample through manganese permutit, regenerating later with 10 per cent potassium permanganate.—*R. E. Thompson.*

Water Pollution in Louisiana. PERCY VIOSCA, JR. Trans. Am. Fisheries Soc., 56: 101–7, 1926. From Chem. Abst., 22: 651, February 20, 1928. Oil pollution of streams in Louisiana including sulfuric acid from refineries and salt from wells has been lessened by oil traps and by re-use of the acid. Pollution by paper mill waste is decreased by removal of pulp and oxidation in shallow ponds. Pollution by sugar mill waste is lessened by settling basins, where sedimentation and biological action take place. Pollution from gravel-washing plants can be prevented by keeping clay and sand out of river.—*R. E. Thompson.*

Ground Water Phenomena. W. KOEHNE. Gas- u. Wasserfach, 70: 1161–3, 1927. From Chem. Abst., 22: 651, February 20, 1928. Effect of soil, air, evaporation, seepage, etc., on ground water level is discussed with special reference to water supply.—*R. E. Thompson.*

The Value of pH to the Filter Plant Operator at Plants Where Alum is Used as a Coagulant. S. F. ALLING. Am. Dyestuff Rept., 16: 761–2, 1927. From Chem. Abst., 22: 653, February 20, 1928. Method of chemical control in filter plants by determination and regulation of pH described in simple terms. —*R. E. Thompson.*

An Improved Method for the Determination of Dissolved Oxygen in Water. V. SUBRAHMANYAN. J. Agr. Sci., 17: 468–76, 1927. From Chem. Abst., 22: 654, February 20, 1928. Determination of dissolved oxygen by Thresh's method may lead to discordant results because of loss of iodine, which is carried away by the gas passed through the apparatus during titration. Modified method is described, which eliminates this error and obviates necessity for making separate determinations of dissolved oxygen of reagents used. Corrections for nitrites can be made by making separate determinations by the Griess-Ilosvay colorimetric method. Details of procedure and manipulation in original—*R. E. Thompson.*

Boiler Water Treatment at the Sons of Gwalia, Ltd., Western Australia. V. T. EDQUIST. Bull. Inst. Mining Met., 279: 2-8, 1927; Chem. Eng. Mining Rev., 20: 43-5, 1928. From Chem. Abst., 22: 655, February 20, 1928. Water from wells containing sodium chloride 70.82, magnesium chloride 33.03, calcium chloride 26.98, calcium carbonate 11.57, calcium sulfate 22.71, formed scale and was intensely corrosive. Treatment by hot caustic soda process was unsatisfactory. Treatment with lime and barium carbonate (crude witherite) was adopted. Witherite is ground with lime and agitated in tanks with the water for twenty-four hours. Treated water contains sodium chloride 78.3, magnesium hydroxide 0.92, calcium chloride 55.94, calcium oxide 2.94, barium carbonate 1.1, and has given satisfaction for three years.—*R. E. Thompson.*

Action of Chlorine on Waste Waters. E. DELCOURT-BERNARD. Compt. rend. soc. biol., 95: 886-7, 1926. From Chem. Abst., 22: 657, February 20, 1928. Hydrochloric acid acts as germicide more strongly and more constantly at 1 per 1000 than at 1 per 100. At 1 per 10,000 its action is nearly the same as at 1 per 100. Javel water is strong germicide at all dilutions. Its action at 1 p.p.m. is not much different than at 1 per 100. Dilutions of 1 per 1000 are recommended for both.—*R. E. Thompson.*

What is Important in the Examination and Estimation of Boiler Feed Waters for Heavy Duty Boilers? HAUPT. Chem.-Ztg., 51: 943-5, 1927. From Chem. Abst., 22: 655, February 20, 1928. Critical study of factors of performance of boilers shows that usual estimation of boiler feed water is not sufficient. Among factors to be considered are pretreatment of water, nature of condensate, and water capacity of boiler. Methods of pretreating water are reviewed and criticized and the check made possible through condensate is pointed out. —*R. E. Thompson.*

The Germicidal Action of Chlorine Water. ALFRED ROMWALTER. Gas-u. Wasserfach, 70: 1133-6 1927. From Chem. Abst., 22: 657, February 20, 1928. No evidence of radiation capable of affecting photographic plate through quartz was obtained when bacteria were treated with sodium hypochlorite solution. This is contrary to hypothesis of BUNAU-VARILLA and TECHOUEYRES (cf. C.A., 19: 2687) who suggested that diluted sodium hypochlorite solutions emit rays when reacting with organic matter, and that these rays act on microörganisms in manner similar to ultra violet rays. Author also failed to obtain any photographic effect from oxidation of ferrous hydroxide, ammonium hydroxide or organic materials. It is more probable that germicidal effect of hypochlorites is due to reaction of oxygen or chlorine with unsaturated components of the plasma, thus destroying their activity and interfering with metabolism. Only relatively small amount of chlorine is required for this effect.—*R. E. Thompson.*

Cannery Waste Disposal. A. ELLIOTT KIMBERLEY. The Canner, 66: Serial No. 1717, 18-21, 1927. From Chem. Abst., 22: 656, February 20, 1928. Studies reported on peas, green beans, lima beans, corn, succotash, and tomatoes. Attempt has been made to modify cannery waste by oxidation so that pollut-

ing effect is substantially reduced. Data presented on units of pollution in terms of stream demand per day by screened wastes from representative packs and corresponding minimum stream flows required to prevent nuisance and to conserve fish life.—*R. E. Thompson.*

The Disinfection of Water by Chlorine and the Removal of the Excess Chlorine After Disinfection, with Special Reference to Adler's Method. R. GRASSBERGER and F. NOZICZKA. Wiener med. Wochschr., **77**: 1136–7, 1192–4, 1289–94 (1927). From Chem. Abst., **22**: 657, February 20, 1928. Review.—*R. E. Thompson.*

Purification of Surface Water for Household and Industrial Use. H. HAUPT. Z. Untersuch. Lebensm., **54**: 22–33, 1927. From Chem. Abst., **22**: 652, February 20, 1928. Discussion and review.—*R. E. Thompson.*

Tests on Quick-Hardening Cements. The Research Laboratory of Civil Engineering. Rept. No. 4: 72 pp. 1926. From Chem. Abst., **22**: 672, February 20, 1928. Physical properties of 4 quick hardening cements—Ciment Fondu, Atlas Lumnite, Dyckerhoff Doppel, Ferro Concrete—are compared with ordinary portland cement.—*R. E. Thompson.*

Closing Breaks in Water Lines. HUGO VIERHELLER. Tonind. Ztg., **51**: 1807–8, 1927. From Chem. Abst., **22**: 673, February 20, 1928. Mixture of neat aluminous cement with 20 to 50 per cent portland is made up which will give initial set of two to three minutes and final set of four to five minutes. Slight excess is mixed dry, and correct amount of water added, mixed very rapidly, kneaded into ball and shoved into hole, after which a layer of aluminous cement mortar is applied.—*R. E. Thompson.*

Cement Tests Made by Thirty-Two Laboratories. Japan Soc. for Portland Manuf., 3 pp. September, 1927. From Chem. Abst., **22**: 673, February 20, 1928. Maximum, minimum, and average results given for test samples tested by 32 laboratories.—*R. E. Thompson.*

Effect of Calcium Chloride on Some Physical Properties of Portland Cement. SHICHIRO UCHIDA. Rept. Sendai Higher Tech. School Research **4**: 1–9, 1926. From Chem. Abst., **22**: 674, February 20, 1928. Calcium chloride when used within certain limited proportions accelerates setting and hardening of cement and increases tensile strength of neat or sanded cement.—*R. E. Thompson.*

Corroson Detected by D.O.C. Test. H. J. YOUNG. Oil and Gas J., **26**: 27, 146, 148, 158, 1927. From Chem. Abst., **22**: 682, February 20, 1928. Direct oil corrosion test consists in running warm oil over warm steel, or other metal, polished to degree produced by No. 0 emery, at 10° below the boiling point of water and examining the surface microscopically. Test shows effect of 0.002 per cent sulfuric acid or small quantities of sea water, alkalies, sulfates, etc.—*R. E. Thompson.*

Water in the Tannery. M. AUERBACH. Ledertech. Rundschau, **19**: 256-7, 1927; Cf. C.A., **21**: 4090. From Chem. Abst., **22**: 696. February 20, 1928. Water should contain little organic matter and few bacteria.—*R. E. Thompson.*

Laboratory Communication. J. H. LINSCHOTEN. Chem. Weekblad, **24**: 558-9, 1927. From Chem. Abts., **22**: 699, March 10, 1928. For evaporation of large amounts of liquids from dish with continuous supply from bottle, a double-bore cork is used with short narrow tube and long wide tube with beveled lower edge.—*R. E. Thompson.*

The Composition of Bleaching Powder. I. E. A. O'CONNOR. J. Chem. Soc., 1927, 2700-10. From Chem. Abst., **22**: 738, March 10, 1928. Roughly, composition of sample of bleaching powder, containing 35 per cent available chlorine, is $2Ca(ClO)_2 + CaCl_2 + 3Ca(OH)_2 + 4H_2O$.—*R. E. Thompson.*

Air Blower Removes Sticks and Débris from Concrete Aggregates. B. E. TORPEN. Eng. News-Rec., **100**: 599, 1928. A brief illustrated description of arrangement used during construction of Bull Run dam for water supply of Portland, Ore., to remove sticks and débris from concrete aggregates. Concrete made from aggregates containing 2 per cent of such material by volume showed 15 per cent loss in strength and very poor workability.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Crazing and the Growth of Hair Cracks in Concrete. ALFRED H. WHITE, WILHELM A. AAGAARD and AXEL O. L. CHRISTENSEN. Eng. News-Rec., **100**: 481, March 22, 1928. Crazing is due mainly to rapid evaporation of water from surface of rich mortar or concrete. Surface becoming dry tries to contract but is restrained by main body of material which is still wet and swollen. Surface is thus placed in tension and hair cracks result. Portland cement, after hydration, is mixture of crystals and colloidal material, and latter expands when wet and contracts when dry. Same forces which cause hair cracks may also make them larger and deeper, so that they may become structural cracks. Crazing may be prevented by use of lean mixtures and by keeping moisture content of concrete constant. Protective coatings and integral waterproofings of water-repellent type are helpful. If integral waterproofings are used, care must be taken to keep concrete damp until adequate strength is developed.—*R. E. Thompson.*

Progress of Studies of Crazing of Cement Mortars. P. H. BATES and C. H. JUMPER. Eng. News-Rec., **100**: 482, March 22, 1928. Series of panels have been under observation at Bureau of Standards. There appears to be some slight evidence favoring mixes with high sand area-cement ratio. After one and one-half years' work nothing very tangible in solving problem has been discovered.—*R. E. Thompson.*

Trend of Portland and Accelerated Portland Cement Compositions. EDWIN C. ECKEL. Eng. News-Rec., **100**: 617-8, 1928. It is shown by means of triaxial diagrams that trend in manufacture of cement is towards the produc-

tion of tri-calcium silicate. The early strengths of accelerated portland cement concrete, up to six months at least, are more than 25 per cent in excess of portland cement concrete strengths.—*R. E. Thompson (Courtesy Chem. Abst.)*.

Po River Flood Control Works—Some Observations. Eng. News-Rec., **100**: 506-7, March 29, 1928. Conclusions contained in monograph by John R. Freeman are reproduced.—*R. E. Thompson.*

Practices in Placing Vitrified Clay Liner Plates in Sewers. Eng. News-Rec., **100**: 428-30, March 15, 1928. Review of construction practice in placing salt glazed vitrified clay liner plates in sewer pipes. Plates are ridged on one side with longitudinal dovetail ribs for bond with concrete. This type of lining is being employed in sewers under construction in several cities.—*R. E. Thompson.*

Devices that Aid Laboratory Studies on Concrete. Eng. News-Rec., **100**: 432-3, March 15, 1928. Illustrated description of equipment of materials-testing laboratory of University of California, including apparatus for determining permeability.—*R. E. Thompson.*

Operation and Maintenance of Distribution System of Spring Valley Water Co. Geo. Pracy. Eng. News-Rec., **100**: 838-41, May 31, 1928. Operation and maintenance of city distribution system costs about $500,000 and routine construction an equal amount per year. Company supplies average of 55 million gallons per day, using for this purpose, within city, 5 steam pumping stations, 10 electrically driven stations, 8 of which are automatically operated, 7 reservoirs, 12 tanks, 750 miles of pipe, and 105,000 services and meters. Topography of San Francisco in very uneven, elevations varying from sea level to 930 feet. Area of city is about 41 square miles. Cement joints have been used in laying cast iron pipe for 11 years with entire satisfaction. No routine examination of gate valves is made and no trouble has been experienced on that account. Night emergency crew consists of 1 man only. The minimum size of service is ¾-inch. There is no maximum limit; largest service in use is 8 inches. Services are installed in advance of paving when property owner pays for cost of work, average value being refunded to him when service is put in use. On services up to 2 inches, a single disc meter is used; above 2 inches, batteries of 2-inch meters are employed. Detector check meters are placed on sprinkler connections, all water passing through main pipe not being registered. Weeds are removed from reservoirs by means of a drag. Occasional trouble with muddy water during rainy season has been overcome by applying alum to water entering reservoir. Floc formed completely settles mud in reservoir, leaving water absolutely clear.—*R. E. Thompson.*

Experiences with Blind Taps and a New Marker. Frederick W. Albert. Eng. News-Rec., **100**: 870-1, May 31, 1928. Knoxville, Tenn., recently abandoned use of curb cock-box, incorporating curb cock in meter casing. To take

place of box which previously indicated position of blind taps, a marker has been developed consisting of 4-inch cast iron disc threaded on to 3 feet of ¾-inch scrap pipe. Cost of marker is 18 cents compared with $1.33 for curb cock-box. —*R. E. Thompson.*

Construction Progress on Hetch Hetchy Aqueduct. Eng. News-Rec., **100**: 614–6, April 19, 1928. Tunnel driving in foothill division of Hetch Hetchy aqueduct, San Francisco's mountain water supply project, is almost completed. This will bring new Tuolumne River supply to east side of main San Joaquin Valley, where 2 major projects, the 47.4-mile pipeline across valley and the Coast Range division (including 28.6 miles of tunnel) remain to be constructed. If $24,000,000 bond issue is passed May 1, construction program is arranged to deliver supply to city mains in 1932. Purchase of distribution system of private company is under consideration, and $41,000,000 bond issue for this purpose will also be voted on at May 1 election. Net tunnel length in foothill division is 15.85 miles, of which 8.60 miles is being built by city forces and 7.25 miles by contract. Concrete lining will be placed in about 40 per cent of total length. Lining is to have minimum thickness of 6 inches, will not be reinforced except for few special sections in soft ground and will require about 2 cubic yards per lineal foot. Cross-sections of 2 sizes were used, 10½ and 14½ feet high respectively, both of horseshoe shape, size difference being that required to compensate for difference in smoothness of lined and unlined sections. As part of foothill division, the so-called Moccasin regulating reservoir is being constructed. Here, water from tunnels of mountain division that has passed through Moccasin Creek power plant will be collected at foothill division intake. Reservoir will be formed by 2 dams constructed 2500 feet apart in natural bed of stream, one above power house and other below foothill tunnel intake. Natural flow of creek will be bypassed through reinforced concrete conduit 10 feet in diameter to be constructed between the two dams along stream channel in bottom of reservoir. Downstream dam will be earth- and rock-fill structure 800 feet long and 55 feet high, containing 125,000 cubic yards of material. Reservoir capacity will be 550 acre-feet. Coast range tunnel capacity will be only 250 m.g.d., compared with 400 m.g.d. of foothill and mountain divisions. Duplicate tunnel parallel with coast range tunnel will be constructed when warranted by demand.—*R. E. Thompson.*

St. Francis Dam Catastrophe—A Great Foundation Failure. Nathan A. Bowers. Eng. News-Rec., **100**: 466–72, March 22, 1928. Profusely illustrated discussion of failure of St. Francis dam of Los Angeles aqueduct system, which occurred on night of March 12. Dam was of concrete gravity type, although arched in plan. It was located in San Francisquito Canyon, 1½ miles above power house 2 of Los Angeles Power Bureau, roughly 45 miles north of Los Angeles. Reservoir which it formed had capacity of 38,000 acre-feet and was practically full at time of break. Flood washed away the concrete power house and buried great stretches of valley under silt. It reached Santa Paula, 46 miles below dam, 3 hours after break, thus averaging 15 miles per hour or 22 feet per second in its advance. Rough estimates indicate that peak flow exceeded 400,000 or 500,000 second-feet. By 6 a.m. flow had subsided to bank

storage and return waters. Great blocks of the concrete mass, weighing many thousands of tons, were carried half mile or more down canyon. Dam had impounded water last year, but according to present information, had not been full until shortly before break. Seepage beneath and around dam on day previous was only of reasonable quantity, and was clear as usual. Only 100-foot length near center of original 650-foot length remained standing erect. Concrete was strong and sound enough to shear through aggregate. Some fragments have rock still adhering to their base. Consensus of opinion (March 16) was that foundation conditions were at least important factor, if not sole cause of break. Dam was designed by Los Angeles Bureau of Water Works and Supply, and built by Bureau by day labor. It was planned and built without check or supervision by state. California law (of 1917), which requires plans for all dams to be approved by state engineer, exempts those built by California Débris Commission, municipal corporations which have a department of engineering, and water systems under jurisdiction of state railroad commission.—*R. E. Thompson.*

St. Francis Dam Failure. An Engineer's Study of the Site. Ralph Bennett. Eng. News-Rec., **100**: 517–8, March 29, 1928. Results of study, essentially substantiating conclusions of N. A. Bowers (cf. previous abstract).—*R. E. Thompson.*

Commission Finds Failure of St. Francis Dam Due to Defective Foundations. Eng. News-Rec., **100**: 553–5, April 5, 1928. Conclusions of commission of engineers appointed by Governor of California are as follows: (1) Failure was due to defective foundations. (2) There is nothing in failure to indicate that accepted theory of gravity dam design is in error, or that there is any question about safety of concrete dams constructed in accordance with that theory when built upon even ordinarily sound bedrock. (3) Failure indicates desirability of having all such structures erected and maintained under supervision and control of state authorities. In January, 1927 reservoir was filled to within 3 feet of spillway level and was kept nearly full throughout 1927. It was practically full when failure occured. Evidence showed little seepage through structure of main dam itself, but seepage through foundation on which dam rested appears to have increased to maximum of 1 to 2 second-feet on afternoon of day preceding failure. Break occurred suddenly and flood attained maximum depth of 125 feet at point near dam. Probable that flood peak immediately below dam exceeded 500,000 second-feet. Details of foundation conditions included. Many of available data indicate that initial foundation failure occurred near or at the old fault or contact between conglomerate and schist in right bank and was due to percolation of water into and through this section of foundation, with resultant softening of conglomerate under dam.—*R. E. Thompson.*

Geological Formation at St. Francis Dam Site. Hyde Forbes. Eng. News-Rec., **100**: 596–7, April 12, 1928. Geological formation at dam site described and weaknesses pointed out.—*R. E. Thompson.*

Notable Dam Failures of the Past. Eng. News-Rec., **100**: 472–3, March 22, 1928. Brief data given on 18 dam failures.—*R. E. Thompson.*

St. Francis Dam Catastrophe. A Review Six Weeks After. Nathan A. Bowers. Eng. News-Rec., **100**: 727–33, May 10, 1928. All important data relative to dam and its failure that have been brought to light are assembled Incompetence of foundation materials has been established beyond reasonable doubt as cause of failure. Disaster is not an indictment of modern practice in dam design, as, aside from fundamental necessity of testing and proving quality of underlying material, this structure lacked deep-set foundations, adequate cut-off wall, foundation drains, foundation grouting or other provisions for preventing water from getting underneath dam. It provides impressive example of danger in centering great responsibility in one man, no matter what his capabilities, without providing independent opinions to check his judgment.—*R. E. Thompson.*

Reports of Four Boards of Engineers and Geologists. Eng. News-Rec., **100**: 733–6, May 10, 1928. Essential portions given of reports of following boards who have investigated failure of St. Francis dam: a board of geologists appointed by Los Angeles Board of Water and Power, the District Attorney's Technical Commission, the Coroner's Jury which was made up of engineers, and the Engineering Committee of the City Council (Los Angeles). The reports agree fully in main findings, attributing failure to defective foundations. Reform of state legislation is demanded in order to place municipal dams under state check of design and construction as required for private dams.—*R. E. Thompson.*

Dam Failure by Sliding a Century Ago. L. J. Mensch. Eng. News-Rec., **100**: 674, April 26, 1928. Brief description of failure of Puentes dam in Spain 120 years ago. Failure of dam, which was of rubble masonry, 167 feet high, 152 feet thick at base, and 900 feet long, was similar to St. Francis dam failure. —*R. E. Thompson.*

Sixth Report on St. Francis Dam Offers New Theories. Eng. News-Rec., **100**: 895, June 7, 1928. Essential data given from report made from Santa Clara Water Conservation District by C. E. and E. L. Grunsky, engineers, and Dr. Bailey Willis, geologist. For first time stress is placed on 2 diagonal cracks through structure, one near each abutment, which are believed to have occurred some months before collapse. Dr. Willis states that east abutment was located on old landslide which became active when soaked with water from reservoir. Engineers conclude: (1) That site was not suitable for dam of type erected. (2) Dams which are rigid should not be selected for locations where minor earth movements are probable. (3) Appearance as early as January, 1928, of cracks in dam, other than temperature cracks, indicated a movement of dam. Thorough studies at that time should have disclosed most of facts now known as to unfavorable features of site. (4) Failure was due to unsuitability of foundation for type of dam built.—*R. E. Thompson.*

St. Francis Dam Failure. Eng. News-Rec., **100**: 638, April 19, 1928. Discussions by J. W. LEDOUX and LETSON BALLIET.—*R. E. Thompson.*

The Structural Safety Factor in the St. Francis Dam. LARS R. JORGENSEN. Eng. News-Rec., **100**: 98-3, June 21, 1928. Discussion from point of view of structural safety. During construction the poor quality of rock against which concrete was poured was very apparent, as also was unscientific method employed in mixing concrete. Average weight of specimens taken from dam was 140.6 pounds per cubic foot, which is 8 per cent less than weight of ordinary good concrete. Failure believed by writer to be due to tension in upstream face. The 66.5 per cent (of height) base width is not conservative for high straight gravity dam or for ungrouted gravity arch dam.—*R. E. Thompson.*

To-day in the Missippi Flood Area. W. W. DEBERARD. **I. Land and People of the Upper Basin.** Eng. News-Rec., **99**: 828-31, November 24, 1927. **II. Closing Mound Landing Crevasse.** Ibid. 870-2, December 1. **III. In the Mid-Section of the River.** Ibid., 917-9, December 8. **IV. What New Orleans Thinks of Flood Protection.** Ibid., 1002-6, December 22. **V. The Sugar Cane Industry and Atchafalaya Crevasses.** Ibid., 1043-6, December 29. **VI. The Cairo Problem and Its Proposed Solutions.** Ibid., **100**: 311-6, February 23, 1928. **VII. New Levee Designs and Their Construction.** Ibid., 398-402, March 8, 1928. **VIII. Revetment and Some River Hydraulics.** Ibid., 434-9, March 15. **IX. The Cypress Creek Diversion Down the Boeuf River.** Ibid., 512-6, March 29.—*R. E. Thompson.*

Earth Moving in Mississippi Flood Control. GEO. B. MASSEY. Eng. News-Rec., **100**: 592-5, April 12, 1928. Discussion of problem and appraisal of types and capacities of equipment available.—*R. E. Thompson.*

Provisions for Flood Control Under New Law. Eng. News-Rec., **100**: 824-5 May 24, 1928. Abreviated text given of Jones-Reid bill (S. 3740), which provides for governmental action in protecting Mississippi Valley from repetition of disastrous floods of 1927. Project as outlined in report of Chief of Engineers (Gen. JADWIN) is adopted, $325,000,000 being authorized for purpose. Local contributions are not required, although the principle is endorsed. Project will be prosecuted by Mississippi River Commission under direction of Secretary of War and supervision of Chief of Engineers. Flood liability is not assumed.—*R. E. Thompson.*

Flood Control Through Slope Correction. W. E. ELAM. Eng. News-Rec., **100**: 996-1001, June 28, 1928. Possibility of applying principle of uniform discharge through uniform slope and channel width to Mississippi problem is discussed. Control may be attained through revetment, levees, delta reservoirs and possibly channel shortening.—*R. E. Thompson.*

Water Consumption and Sewage Discharge at Denver. S. T. WELLER. Eng. News-Rec., **100**: 556-60, April 5, 1928. Litigation by irrigation interests designed to compel city to increase volume of stored water sent down South

Platte River has resulted in detailed study of water consumption and sewage discharge. Considerable part of summer water supply of city is drawn from its reservoirs, Lakes Cheesman, Antero, and Marston. As large part of this stored water reaches river through sanitary sewers, amount available for use of irrigation interests below Denver is materially increased. The irrigation interests have resisted every attempt of city to increase its use of direct rights, and in this way hope to compel city to build additional reservoirs. Methods employed in study are described in some detail. Data obtained indicate that actual return of water used for strictly domestic and factory purposes to the river by way of sanitary sewers is about 95 per cent. At present consumption this represents loss of about 2.5 m.g.d. Loss by leakage from distribution system is believed to be less than 1 per cent of water delivered for domestic use, or 0.5 m.g.d. This would be equivalent to 656 gallons per mile of pipe per day, or 66 gallons per day per inch-mile of pipe. Author believes assumption that "water unaccounted for," frequently reported as 15 to 40 per cent, is largely leakage is entirely unwarranted. These percentages of water unaccounted for are no greater than errors known to exist in large number of service meters used. Estimates of leakage from distribution system based on such data are entirely without value and extremely misleading.—*R. E. Thompson.*

Semi-Cylindrical Steel Caisson Aids in Cutting Sea Wall. Eng. News-Rec., **100**: 600, April 12, 1928. In enlarging steam power plant of Pacific Gas and Electric Co., at Oakland, Cal., it became necessary to install a 48-inch cast iron pipe for circulating water, intake being in concrete sea wall 20 feet below high-tide level, where concrete is 10 feet thick. Semi-cylindrical steel caisson employed is described and illustrated.—*R. E. Thompson.*

Water Pipe Fifty-Eight Years in the Ground is Still Serviceable. Eng. News-Rec., **100**: 589–90, April 12, 1928. Spring Valley Water Co., serving San Francisco, recently removed 30-inch riveted water main which had been in ground fifty-eight years. After cleaning, the 30-foot sections were found to be still in serviceable condition and in all probability most of them will receive new protective coating and be again put in service. Plates from which pipe was made are of wrought iron, $\frac{1}{8}$ inch in thickness. Protective coating consisted of natural asphalt mixed with varying amounts of coal tar. Pipe, which was operated under pressure of 55 pounds per square inch, had been out of service since 1922 but was left in ground until street grading necessitated its removal. Outside of pipe was in almost perfect condition. Inside was tuberculated over entire area, tubercles being mostly $\frac{1}{2}$ inch high, with some rising to 1 inch. Under tubercles, large shallow pits were found $\frac{1}{64}$ to $\frac{3}{64}$ inch deep. Pipe was in sandy yellow clay.—*R. E. Thompson.*

Ancient Chinese Method Used to Close Levee Breaks. O. J. Todd. Eng. News-Rec., **100**: 587, April 12, 1928. Brief illustrated description of method used in closing levee break on Yellow River (China) dike, consisting of placing in breach plugs of Kaoliang (tall millet) and clay wound with bamboo rope.—*R. E. Thompson.*

Rod for Cross-Sectioning in Tunnel. C. C. Keely. Eng. News-Rec., **100**: 598, April 12, 1928. Brief illustrated description of tunnel cross-sectioning rod designed during tunnel work at Power Plant No. 1, at Saugus, Cal., Los Angeles Bureau of Power and Light.—*R. E. Thompson.*

Public Water Supplies in Illinois. Eng. News.Rec., **100**: 775, May 17, 1928. Brief tabulation, prepared by State Department of Health, shows condition of public water supplies in Illinois for years 1921 and 1928. The Department acts only in advisory capacity, having no authority to require cities or companies to make water safe according to standards set by the Department.—*R. E. Thompson.*

Corrosion of Metal in Pipes and Flumes in Imperial Valley. Eng. News-Rec., **100**: 590, April 12, 1928. Data given on corrosion of pipes and flumes used by Imperial Irrigation District. Fact that flumes suspended in air show similar action to that in pipes in ground shows that cause of corrosion is in water and not in soil. More rapid action in lower part of wetted perimeters suggests possible relationship between corrosion and heavy silt content of water. Another possible explanation is the high oxygen content. A flume 4 inches wide made of 14-gage metal, suspended above the ground, had to be replaced after three years' service because of holes corroded entirely through metal. Corrosion was most pronounced at points where metal bands passed around flume and at joints where a slight irregularity in bottom was caused by crimping of metal plate to receive compression ring that made joint. A 6-foot pipe buried 20 feet below surface of ground recently collapsed after nine years' service due to many holes corroded through lower part of pipe.—*R. E. Thompson*

Large-Section Tunnel Construction at Asheville. E. L. Hageman. Eng. News-Rec., **100**: 441–3, March 15, 1928. Illustrated description of construction of traffic tunnel at Asheville, N. C., 920 feet long. Inside concrete-lined section is 39 feet 2 inches wide by 22 feet high, excavation section being approximately 48 by 27. About 130 feet of tunnel is through soft material, and remainder through solid rock. Concrete mix for lining, containing 5 per cent diatomaceous earth for waterproofing, will be placed behind steel forms with air-driven concrete gun.—*R. E. Thompson.*

Louisville Adds Pumps and Filters. Eng. News-Rec., **100**: 858, May 31, 1928. Material enlargements are approaching completion at Louisville, Ky., including new pumping equipment at raw- and filtered-water pumping stations, and new filter house, with filters having rated capacity of 48 m.g.d., supplementing old 72-m.g.d. filters.—*R. E. Thompson.*

Are Cemeteries a Danger to Springs in the Vicinity? J. Hug. Schweiz. Ztschr. f. Gesundheitspflege, 1927, **7**: 803–7. From Bull. Hyg., **3**: 660, August, 1928. This writer has collected from the literature a number of opinions of authorities on this subject. All of them indicate that there seems to be no danger from this source to adjacent water supplies. At Rümlang, in the can-

ton of Zürich, the community has used water for a hundred years from a cistern, the supply of water for which comes from a churchyard 5 meters away. No ill effects on the inhabitants have ever been noted.—*Arthur P. Miller.*

The Preservation of the Purity of River Water with Regard to Pisciculture. W. RUSHTON. J. Soc. Eng., 1927, 18: 183–92. From Bull. Hyg., 3: 661–662, August, 1928. The Royal Commission on Sewage Disposal proposed a standard to which sewage effluents should conform, but this article points out that the commission did not say that an effluent of the standard suggested would support fish life. It is not impossible to obtain such effluents. The necessity of food supply in the water to fish life and the harmfulness of sewage and trade wastes in excess to both the fish and their food supply are covered. The demands of the fish culturist might be briefly summed up to be: (1) that waters shall be in as nearly natural condition as possible; (2) that effluents entering shall not kill fish or reduce fish food; (3) that the standard of an effluent shall be that it will support live fish; (4) that in the cases of all new works, the operating experiences with others of same type shall be used in the design so that a polluting liquor will not eventually be discharged from said new plant. Comments of several other persons on this subject, particularly with relation to fish and food life in waters and deleterious products discharged by industries, are included.—*Arthur P. Miller.*

Manganese in Water Supplies of the Rhine Province. K. KISSKALT. Arch. f. Hyg., 1928, 99: 96–8. From Bull. Hyg., 3: 663, August, 1928. The article cites the occurrence of manganese in water at Breslau, Stettin, Dresden, and Cairo. At Lohmar bei Siegburg, black masses on the pipes near the spring proved to be manganese and a test of the water gave 0.4 p.p.m. Upon further investigation, presence of Mn in water was found to be not uncommon although usually of a local nature.—*Arthur P. Miller.*.

Chlorine Absorption of Water. H. WETTE. Arch. f. Hyg., 1928, 99: 143–57, From Bull. Hyg., 3: 665, August, 1928. A measurement of chlorine absorption is useful in providing a better criterion of the presence of certain albuminoid bodies than does the oxygen absorbed test (as measured by the Kubel-Tiemann process) and in giving an indication of the amount of chlorine needed in the disinfecting process of water purification. Various methods of testing for chlorine absorption, the results of which depend somewhat on the method employed, are discussed. Test samples of boiled tap water to which urea had been added were subjected to the following three methods of obtaining chlorine absorption: (1) FROBOESE method; large excess of reagent and heating: (2) BRUHNS method; addition of 1 to 2 p.p.m. of chlorine; reaction in cold followed by titration of excess: (3) OLSZEWSKI method; testing for slight excess with benzidine. It was concluded that albuminoid substances like urea, carbohydrates represented by sugar, and fats represented by olive oil do not affect dose required for chlorination. Other experiments indicated that a high bicarbonate content and pH value favor high chlorine absorption. —*Arthur P. Miller.*

The Rôle of Ammonia in the Purification of Water. C. H. H. Harold. J. Roy. San. Inst., 1928, **48**: 484–8. From Bull. Hyg., **3**: 666, August, 1928. After a brief discussion of the use of ammonia and chlorine together in the disinfecting process, the author describes the use of these two chemicals for purifying water in the field with the British army. Both monochloramine and dichloramine are used; the latter being substituted for the former when the water is charged with excessive amounts of urine and nitrates. The process of disinfecting with these substances is given in detail.—*Arthur P. Miller.*

Report on the Working of the Corporation Water Analysis Laboratory for 1926. S. V. Ganapati. Ann. Rep. Health Officer of the City of Madras for Year 1926. 100–114. From Bull. Hyg., **3**: 666–667, August, 1928. The bacteriological quality of the raw water at Madras is spoken of as "fair" and that of the water "passing into the supply" as "much the same as the raw water." Vibrios appeared in the water in July, 1926, and chlorine was resorted to with but little effect because H_2S took it up. Tests showed variable vibrio content but they were found not to be true *V. cholerae.* An investigation showed that the nightsoil of several hundred people at the shore of the Red Lake source of supply was directly responsible for the major pollution.—*Arthur P. Miller.*

Types of Hydrants for Coach Yards and General Service and Methods for Supplying Water to Coaches. Com. Rep. Amer. Ry. Engr. Assoc. Proc., **29**: 158–176, 1928. The most suitable type of hydrant for coach yards and station platforms is a quick opening, self draining, non-freezing valve in pit or box flush with the surface. Copious diagrams and charts are included.—*R. C. Bardwell.*

Pipe for Service Lines, Three Inches and Under in Size, with Particular Reference to the Use of Prepared Joint Cast Iron Pipe and Copper and Brass Pipe as Substitutes for Steel and Wrought Iron Pipe. Com. Rep. Amer. Ry. Engr. Assoc. Proc., **29**: 177–186, 1928. Report recommends consideration of small size cast iron pipe for permanent service lines, extra heavy galvanized wrought iron for semi-permanent, and against use of uncoated iron or steel pipe. For service lines one inch or less, copper pipe is suggested instead of lead. Reduction in number of pipe sizes is recommended.—*R. C. Bardwell.*

Progress Report of the Committee of the Sanitary Engineering Division on Filtering Materials for Water and Sewage Works. Discussion. Proc. Am. Soc. Civ. Eng., **54**: 7, 2213–18, September, 1928. J. W. Armstrong. The plan for studying the optimum size of filter sand and the depth of filter beds is briefly outlined. Cities in different parts of the country are coöperating in the work. H. N. Jenks. There was no appreciable difference in the quality of water at Sacramento, Calif., whether from filters in which the sand depth was 30 inches or from those in which it was 24 inches. There appeared to be less air-binding in the beds of lesser depth. A study is being made of means whereby a sewage filter bed may be readily "de-clogged" so as to permit the

use of the most efficient filtering material regardless of its tendency to become clogged. The durability of materials used for sewage beds is of prime importance. J. N. CHESTER. It is believed that no amount of experimenting or standardizing can compensate for changes that are likely to take place in many of the water and sewerage plants of the country. The question as to what is the paramount factor guiding such experiments is raised. Is it purely economics, or is it the quality of the water to be derived from the filter?—*John R. Baylis.*

Administrative Water Problems. A Symposium. Discussion. Proc. Am. Soc. Civ. Eng., 54: 7, 2177–86, September, 1928. M. C. HINDERLIDER. The Colorado laws regulating the use of water from natural streams are discussed. Colorado has approximately 1,000 storage reservoirs. The law provides that water may be released from reservoirs, transmitted down natural streams and taken out again by the water owner, under the supervision of the State water officials. The water lost in transit by seepage and evaporation has to be determined by the State Engineer. The losses vary from 2 to 30 per cent of the water released from the reservoirs. Details as to how to arrive at these losses are given. R. I. MEEKER. The losses of water in transit are quite variable and the question of properly applying such losses in years when the water is short is frequently fertile ground for water disputes. LYNN CRANDALL. The construction and operation of storage reservoirs for irrigation in the West has resulted in more or less contention between the owners of stored water and the owners of earlier natural flow rights. The difficulty of arriving at a just distribution of the water is discussed. E. B. DEBLER. California adopted riparian rights as the basis of its water rights years ago, but the Courts have usually upheld any uses which do not deprive other riparian owners of their proportionate share of such use.—*John R. Baylis.*

Water Supply Problems of a Desert Region. WILLIAM E. RUDOLPH. Proc. Am. Sec. Civ. Eng., 54: 8, 2287–2302, October, 1928. This paper discusses some of the water supply problems of the Atacama Desert of Northern Chile. The projection of water works in such a region involves many problems. At elevations below 10,000 feet the rainfall has averaged only 0.04 inches per year. and the Desert of Atacama is one of the most barren on the earth's surface. A single stream, the Rio Lao, with a maximum flow of 130 cubic feet per second, decreasing to 67 cubic feet per second as it crosses the desert, reaches the Pacific. This little stream supplies the Antofagasta nitrate pampa, the copper plant at Chuquicamata, and the City of Antofagasta, and contributes to the operation of three railroads and to the irrigation of farm lands. The supply of the City of Antofagasta is conveyed 230 miles. The pipe lines of this region are usually of steel or cast iron. Where the lines cross low valleys the pressure may be as high as 1000 pounds per square inch. In some localities the cost of delivering the piping material far exceeds the cost of the pipe. Because of the corrosive quality of the water, it is highly important that the air be excluded from the pipe lines. The water for many of the villages is supplied from tank cars. Twenty-six gallons per day per inhabitant within cities and half of that quantity outside of cities, are the quotas on which the

Chilean Government bases concessions for drinking water supplies in the desert provinces. The seaport of Tocopella obtains its water by distillation of the ocean water.—*John R. Baylis.*

The Sanitary Significance of Lactose-Fermenting Bacteria Not Belonging to the B. Coli Group. I. Groups Reported in the Literature and Isolated From Water in Chicago. Frank E. Greer. Jour. Infect. Dis., 42: 5, 501–513, May, 1928. According to the literature, the most common types of lactose fermenting bacteria found in water are *Cl. welchii, B. aërosporus* and *St. fecalis.* Less common are the leather bacillus of Houston, *Phytomonas aërogenes* and an anaërobe described by Raab. *Cl. welchii, B. aërosporus, St. fecalis,* the leather bacillus, and members of the mucosus-capsulatus group were isolated and identified from the Chicago water supply. **II. Number of Lactose Fermenting Organisms Found in Chicago Sewage and Chicago Water Supply.** Franck F. Greer. Jour. Infect. Dis., 42: 5, 514–524, May, 1928. The numbers of *Cl. welchii, B. coli, B. aërosporus* and *St. fecalis* mentioned in section I vary seasonally and in the raw and treated water. "They often render the 48-hour presumptive test of treated water valueless as an index of *B. coli* during many months of the year." **III. Bacterial Associations in cultures Containing Lactose-Fermenting Bacteria.** Frank E. Greer and Florence V. Nyhan. Jour. Infect. Dis., 42: 6, 525–536, June, 1928. "A review of the literature reveals that *B. coli* is outgrown and inhibited in culture mediums by several bacteria found in water. Evidence is also presented that combinations of organisms found in water may give rise to gas production which is not due to the presence of *B. coli.*" Experimental combinations of lactose fermenting types gave the following order of survival after incubation in standard lactose broth: *twenty-four hours incubation—B. coli, Cl. welchii, Ps. pyocyaneus, St. fecalis,* and *B. aërosporus*; *forty-eight hours incubation—St. fecalis, Ps. pyocyaneus, Cl. welchii, B. coli,* and *B. aërosperus.* The condition of culture media, age and variety of cultures, relative numbers of organisms, and the like may influence and distort the indicated experimental order of survival. The authors conclude that the presence or absence of gas formers in lactose broth is not necessarily indicated by the production or absence of gas. The results obtained at the end of the standard methods procedure may not and often do not reflect the condition of the sample at the beginning of the procedure, especially when the forty-eight-hour presumptive test is involved. **IV. Pathogenicity.** Frank E. Greer, Fred O. Tonney, and Florence V. Nyhan. Jour. Infect. Dis., 42: 6, 537–544, June, 1928. "A survey of the literature reveals that only two common lactose fermenting organisms, other than *B. coli,* are found in association with pathological conditions in man. These are *Cl. welchii* and Friedlander's group. *Cl. welchii* has been incriminated in various morbid conditions, and recently attention has been centered on its rôle in pernicious anemia, acute intestinal obstruction, and peritonitis. It also has been associated with some types of water-borne diarrhea." *B. aërosporus* and *St. fecalis* used in the experiments were not pathogenic to the test animals; this finding confirms the work of others. Members of the mucosus-capsulatus group are definitely pathogenic. They have not been found in large numbers in water. When present they

are usually classified in the *B. coli* group. *Ps. pyocyaneus*, usually found with *B. coli* in water by the authors is regarded by them as sufficient evidence for condemning such water. Experimental evidence tends to show that *Cl. welchii* may cause diarrhea when taken by mouth. **V. Factors Influencing the Survival of Microörganisms in Water.** Frank E. Greer. Jour. Infect. Dis., **42**: 6, 545–550, June, 1928 "A study of factors influencing the longevity of organisms in water and a review of the findings of other workers are presented in this section. *B. typhosus* probably dies in a few days, living longer in cold than in warm water. Hydrogen-ion concentration, temperature, sunlight, and sedimentation all play an important rôle in the survival of intestinal organisms in water. Other factors may also play undetermined rôles." **VI. Sanitary Considerations.** Frank E. Greer. Jour. Infect. Dis., **42**: 6, 551–555, June, 1928. "The sanitary significance of the lactose-fermenting organisms has been discussed. The conclusions reached are that, besides *B. coli*, *St. fecalis*, *Cl. welchii*, and *Ps. pyocyaneus* may be of sanitary significance. *Streptococcus fecalis* is probably of as great sanitary significance as *B. coli*, while *Cl. welchii* and *Ps. pyocyaneus* are not so significant but may nevertheless possess some significance. Of all the lactose-fermenting organisms so far reported in water, *B. aërosporus* is probably the one that can be dismissed as being of no sanitary significance." **VII. Mediums and Methods.** F. E. Greer, R. E. Noble, F. V. Nyhan and A. E. O'Neil. Journal of Infectious Diseases, **42**: 6, 556–567, June, 1928. "In water analysis the tendency has been to develop mediums which are highly selective for *B. coli*. Such mediums have in some instances been inhibitory to *B. coli*, or have allowed the development of extraneous forms which may confuse or render worthless the test as an index of *B. coli*. Several plate mediums have been developed for enumerating directly the number of *B. coli* and this field offers promise of helpful results." Development of the presumptive, partially confirmed, and completed tests and their modifications are traced from the inception of each to their present status. Experimental results are given of work done with lactose bile, brilliant green lactose bile, Endo and eosin-methylene blue agar, and the completed test. "Bile in concentrations sufficient to kill *B aërosporus* is inhibitory for an appreciable percentage of *B. coli*. Brilliant green bile in the concentrations used in the coöperative study, gives a lower *B coli* index than does lactose broth. It has the advantage of being highly selective for the *B. coli* group. In our experience eosin methylene blue is a more satisfactory medium than is Endo's agar for the partially confirmed test of water analysis. Neither of these mediums is highly selective for *B. coli* and a considerable percentage of growths which are suggestive of *B. coli* are not confirmed as such." Until further evidence accumulates, favoring a different method, the authors favor adherence to the standard methods procedure. **VIII. Conclusions.** Frank E. Greer and R. E. Noble. Jour. Infect. Dis., **42**: 6, 568–574, June, 1928. *Cl. welchii*, *B. aërosporus*, *St. fecalis*, the mucosus-capsulatus group, *Ps. pyocyaneus*, the leather bacillus, and Phytomonas are briefly reviewed as to character, their general habitat, their relation to bacterial water analysis, and their relative sanitary significance. The development of direct plating methods for enumerating these organisms is considered a promising field for future work.—*R. E. Noble.*

The Minimal "Chlorine Death Points" of Bacteria. Fred O. Tonney, Frank E. Greer, and T. F. Danforth. Amer. Jour. Public Health, 18: 10,1259–1263, October, 1928. An original study to determine the least amount of chlorine necessary to kill vegetative cells of a number of known species of bacteria. Strong standard chlorine solutions in distilled water were prepared from which the test solutions were made by dilution, using orthotolidine test to determine the amount of residual chlorine. Sterile distilled water was used to prepare suspensions of 235 strains of bacteria. The sterilized distilled water had practically no chlorine demand, those portions having an appreciable demand being discarded. The pH of the water used ranged from 6.4 to 7.2. Approximately 100 to 300 test organisms were added per cubic centimeter to the sterilized distilled water in each of two Erlenmeyer flasks. The residual chlorine in one flask was determined immediately and portions of the content of the other flask were used to determine the rate of destruction of the organisms. Fifteen and thirty second periods were used as periods of contact with the chlorine disinfectant. The results are given below:

Dosage of free chlorine required to kill vegetative cells of bacteria in fifteen to thirty seconds

CHLORINE	SPECIES	NUMBER OF STRAINS	SPECIES	NUMBER OF STRAINS
p.p.m.				
0.10	*B typhosum*	21	*B. pyocyaneus*	6
	B. paratyphosum A	6	*C. diphtheriae*	27
	B. paratyphosum B	6	*Achromo bacterium viscosum*	3
	B. dysenteriae	8	*Strep. scarlatinae*	14
	B. enteriditis	4	*Strep. fecalis*	11
	B. proteus	2	*B. suipestifer*	8
	Cl. welchii	8	*B. prodigiosus*	6
	Bruc. melitensis	1	*Bruc. abortus*	1
	Staph. albus	4	*Staph. aureus*	4
	Pneumococcus	4	*Strep. hemolyticus*	11
0.15	*C. diphtheriae*	12	*Strep. morbilli*	2
	Strep. scarlatinae	6	*Staph. albus*	4
	Strep. fecalis'	2	Pneumococcus	5
	Staph. aureus	4	*B. coli* (fecal)	9
	Strep. hemolyticus	10		
0.20	Pneumococcus	4	*B. coli*	10
0.25	*Strep. hemolyticus*	3	*B. coli* (fecal)	9
Total strains..				235

B. coli are the most resistant of all of the organisms tested. Of course, the *Cl. welchii* cells used in these experiments were the vegetative cells and not the very resistant spores. The higher resistance of *B. coli* to chlorine in general indicates that this organism is a very satisfactory test organism in determining the effectiveness of chlorine disinfection of water, milk bottles, etc.—*Chas. R. Cox.*

Observations on Acid Mine Drainage in Western Pennsylvania. R. D. LEITCH. Bureau of Mines, Reports of Investigations, **2889**: September, 1928. This paper relates the results of an attempt by the Bureau of Mines to "determine some of the factors contributing to formation of acid mine waters, the yearly variations in quantity and quality of drainage, effect of mining methods, and various other questions arising in connection with the problem" Two streams receiving mine drainage, one in a high-sulphur, and the other in a low-sulphur bituminous coal district, were selected for study. One stream was 18 miles long and had on it 17 active, 6 inactive, and 2 abandoned mines; while the other was 35 miles long and had on it 7 active, 7 inactive, and 15 abandoned mines. With three exceptions, all mines were drift mines. The coal beds worked are given and also figures on drainage volumes. Data were gathered in both spring and fall wet seasons and dry summer season. Acidity and pH determinations were made from samples taken at regular points. Effort was made also to get samples from all places where different kinds of waters were found. On the first stream, the water was acid from the point of entrance of first drainage to mouth. Mine samples showed wide variations in acidity but fresh working faces were usually alkaline or faintly acid. Water from inactive mines was invariably acid. Gobbed material is an important source of acid water. If it could be kept dry and sealed off, the minimum formation of acid might be expected. The presence or absence of limestone floor in a mine seems to have no effect on the acidity of the water. High-sulphur beds produce more acidity than low-sulphur beds. Chemical neutralization of mine water by mixing it with limestone or lime can be accomplished; but installations to do it would be so costly as probably to force a great many economies. However, much improvement can be had by sealing abandoned workings thereby cutting off one source of much acid water.—*Arthur P. Miller.*

A System of Analysis for Oil-field Waters. C. E. REISTLE and E. C. LANE. Bureau of Mines, Technical Paper 432. More uniformity in methods of analyzing oil-field waters would be helpful, in that results obtained by one analyst could then be interpreted and used by others. At present, many methods of analysis and several systems of computing and expressing results are used. For this reason, the Bureau of Mines methods are set forth in this paper. The writer briefly discusses the collection of samples, the removal of undissolved substances from the sample, the determination of the amount of sample to be used in the analysis, and the determination of the total solids. There then follows the detailed procedure for analysis for calcium, magnesium,

sodium, hydroxide, carbonate, bicarbonate, acidity, chloride, sulphate, and hydrogen sulphide. The article is closed with a discussion of the calculation of the sodium radical concentration and of the reporting of results.—*Arthur P. Miller*.

Proceedings Second Michigan Conference on Water Purification, Detroit, Michigan, October 3–5, 1927. 64 pp. Issued by Michigan Department of Health, Lansing, Michigan. **Rates of Filtration.** James A. Parks. 3–8. This paper records certain observations made on the Detroit filters while operating at various rates higher than the usually accepted standard of 125 m.g.d. per acre. Variations in filter rates were as follows, expressed as millions of gallons per acre per day:

YEAR ENDING	MONTHLY AVERAGE		DAILY	
	Maximum	Minimum	Maximum	Minimum
June, 1926	166.3	138.2	173.6	135.6
June, 1927	183.2	153.8	190.4	149.6

Considering the increase in maximum daily rate from 173.6 to 190.4 m.g.d. per acre the following hydraulic effects are noted: (1) "The time of retention in the mixing chamber was decreased from three minutes, normal rate, to approximately two minutes." (2) "The period of retention in the coagulation basins was decreased from two hours, normal rate, to approximately one and one-half hours, and possibly less, as conditions of high filtration rates are responsible for creating almost straight line flow through the center of the basins." (3) "Increase in the velocity of the water through the flumes which convey the water to the filters, causing the "floc" to be broken into more minute particles." Observations were made on individual filters when operating at 3.8 m.g.d. each (about 150 m.g.d. per acre) and at 4.8 m.g.d. each (about 192 m.g.d. per acre). At 3.8 m.g.d. there was: "(a) considerable decrease in the depth of sand surface pentration; (b) no indication of "mud ball" formation; and (c) a decreased depth of sand compression." The sand shrinkage from the filter walls did not exceed ¼ inch. The average initial loss of head was 1¼ feet. At 4.8 m.g.d.: "the average initial loss of head was 2 feet which, coupled with the decrease in the efficiency of coagulation basins, the increase in the amount of coagulum being carried into the filters, and the breaking up of the "floc" due to the greatly increased velocity of the water as it travels through the filter influent flumes, has the almost immediate effect of reducing the time between the filter washes from 15 to 25 per cent." When rates were from 170 to 180 m.g.d. per acre the applied water was "murky" in appearance though the turbidity of the raw water did not exceed 15 p.p.m. This condition is attributed to the disintegration of the "floc" due to high velocities. The

efficiency of bacterial reduction at various high rates is shown by data given in the following tables:

Results of daily bacteriological and physical tests during months January to April 1927, inclusive

Average rate of filtration 158.8 m.g.d. per acre. Average alum dosage 0.58 grain per gallon

	AGAR COUNTS 20°C.	AGAR COUNTS 37°C.	NUMBER OF 10 CC. LACTOSE-BROTH TUBES PLANTED	NUMBER OF CONFIRMED POSITIVE TUBES	TURBIDITY
Raw	13,101	18	3,535	823	15
Applied	11,862	17	3,535	759	8
Filtered	1,560	3	3,535	239	0.1
Tap	3	2	3,655	1	0.1

The period covered by the foregoing table is representative of the season when it is possible to operate the plant at the lowest rate of filtration.

Results of daily bacteriological and physical tests during months May to August, 1927, inclusive

Average rate of filtration 177.0 m.g.d. per acre. Average alum dosage 0.55 grain per gallon

	AGAR COUNTS 20°C.	AGAR COUNTS 37°C.	NUMBER OF 10 CC. LACTOSE-BROTH TUBES PLANTED	NUMBER OF CONFIRMED POSITIVE TUBES	TURBIDITY
Raw	322	25	3,430	1,1[illegible]	10
Applied	287	18	3,330	1,08[illegible]	8
Filtered	157	16	3,330	287	0.5
Tap	19	4	3,470	19	0.5

The Care and Selection of Chlorine Apparatus. William M. Barron. 13–16. This paper discusses, from the viewpoint of the operator, the kinks and tests that are helpful in the operation and maintenance of liquid chlorine feeding machines." The Depth and Grading of Filter Sand and Gravel. Arthur B. Morril. 22–31. The size and grading of the sand layer in a rapid sand water filter is determined by the requirements of filtration. The size and grading of the gravel layer is determined principally by the requirements for back-washing of the filter. The rate of flow of water through the underdrains and upward through the filtering materials is usually at least five times as great as the rate of flow during the filtration process and the losses of head are twenty-five times as great in washing the filter. It is essential that the sand layer

should be floated but that the gravel layers should not be displaced from the relative positions in which they were originally placed. At the bottom where the water issues from the orifices the gravel pieces must be of such size that they will not be moved by the velocity of the water. In a recent study of the characteristics of twenty-five large rapid sand filtration plants in the United States the depth of filter sand was found to vary from 18 to 36 inches. The depth in over half of these plants was 30 inches, the effective size ranging from 0.35 to 0.60 millimeters. The thickness of gravel layers ranged from 6 to 24 inches, the 6-inch depth of gravel being used in conjunction with a Wheeler filter bottom. At the Detroit filtration plant the sand layer is 30 inches thick and has an effective size of 0.45 millimeters and a uniformity coefficient of about 1.6. "In a new design, there appears to be no reason why a 24-inch thickness of sand would not be quite as satisfactory as the 30-inch thickness now used." The graded gravel layer is 17 inches thick and ranges from the coarsest gravel, 2-inch in size, to the finest material between $\frac{1}{16}$ and $\frac{3}{16}$ inch in size. "There has been no evidence that this gravel layer is disturbed even by rates of wash as high as 30 inches per minute vertical rise, but on the other hand there is no conclusive evidence that a somewhat thinner layer of gravel might not be used without affecting results." **Effect of Chlorine on Alum Reaction.** WILLIAM B. MEYER. 35–38. Experiments on the Huron River water at the Flat Rock filtration plant indicate that prechlorination of the raw water at rates in excess of 1 p.p.m. has the effect of reducing the rate of alum feed from 3 grains to 2½ or 2 grains per gallon. The Huron River watershed above Flat Rock embraces an area of about 800 square miles. There are nine dams in this area impounding water in relatively shallow reservoirs. Taste and odors are frequent in filtered water effluents. The Huron River supply has a high absorption for chlorine, treatment at rates as high as 2.5 p.p.m. being necessary during the summer in order to produce a residual chlorine in the filtered water of 0.2 p.p.m. **The Dorr Clarifier in Water Treatment.** IRVING DAHLJELM. 40–42. It is stated that the clarifier installed in the Benton Harbor filtration plant in August, 1922, is the first application of this device to a water purification plant. This paper describes the clarifier and points out certain inefficiencies which have been eliminated in subsequent installations. **Filter Plant Maintenance.** LLOYD C. BILLINGS. 45–50. The public have now acquired confidence in the water delivered from modern purification plants and are becoming more critical of the qualities apparent to them, such as color, turbidity, taste, and hardness. The plant operator's efforts must be directed toward the production of a water which is satisfactory in these respects as well as from the standpoint of bacterial content. The laboratory should be completely equipped and capable of carrying out special work in connection with new construction and experimental investigations as well as routine operating tests. Obsolete plant equipment should be replaced by more modern devices when the maintenance of the old equipment becomes more costly than the carrying charges on more efficient types. Filters at Grand Rapids are renovated periodically once in two years. This involves the removal of the sand and gravel and the cleaning and inspecting of strainer plates and underdrains. Previous work has cost $250 per filter, practically all of which is for labor. It is proposed to employ a portable motor-driven

centrifugal pump to handle gravel and sand in the future, by which it is expected that the cost will be cut in two. 48- and 36-inch sluice gates, originally hand operated, are now operated by a specially designed portable motor and gear. Painting of plant structures and adequate care of grounds pay dividends in increased public interest. A table showing an analysis of the cost of operation of the Grand Rapids filter plant for the fiscal year April, 1926, to April, 1927, is given. **Cementing of Filter Sands.** H. W. Ward. 55–57. Cementing of filter sands is due to incomplete washing of the filters. The best means of eliminating cemented areas from mud balls is raking of sand beds while washing. The procedure at Wyandotte is to wash the filter until the mud is just eliminated, but while there is stll left enough of gelatinous matter resulting from the alum treatment to form a mat. This results in initial loss of head 0.9 to 1.1 feet. When the initial loss of head is less than 0.9 foot, the dirt seems to penetrate farther into the sand and is more difficult to dislodge in subsequent washings. When the initial loss of head is more than 1.1 feet, the filter has not been thoroughly washed and some mud may have been left in the bed.—*R. L. McNamee.*

NEW BOOKS

Principles of Valuation. John Alden Grimes and William Horace Craigue. New York: Prentice-Hall, Inc. Cloth; 6 x 9 inches; pp. 274. $10. Reviewed in Eng. News-Rec., 101: 252, August 16, 1928.—*R. E. Thompson.*

The Municipal Year Book for 1928. Founder and Director, Sir Robert Donald. Edited by Major Arthur Skey, with introduction by Neville Chamberlin, Minister of Health. London: The Municipal Journal. Half leather; 6 x 9 inches; pp. 910. 15s. Reviewed in Eng. News-Rec., 101: 254, August 16, 1928.—*R. E. Thompson.*

Resistance Thermometers. Leeds and Northrup Company, Catalog 80, 1928. The electrical resistance method of temperature measurement is one of the most precise known to science. The calibration of resistance thermometers is corrected with ease and precision to the absolute unit of the thermodynamic temperature scale. In L and N Resistance Thermometers where the highest possible accuracy is required, carefully tested, chemically pure platinum wire is used. Accuracies of the order of 0.02°F. are possible for temperatures up to 200°F., 1.2 up to 900°F., and 5 up to 1800°F., while difference in measurements can be made to 0.0004°F. To secure the full value of the extreme accuracy possible with L and N Resistance Thermometers, Wheatstone bridge measuring instruments are used with them, and the instruments are adjusted well within the guaranteed accuracy of the thermometers.—*A. W. Blohm.*

Chemistry in Medicine. The Chemical Foundation, Inc., New York, N. Y., 1928. A coöperative treatise intended to give examples of progress made in medicine with the aid of chemistry, edited by Julius Stieglitz for the Chemical Foundation. The leading figures in the biological, pre-medical, medical, public

health and engineering sciences have happily joined together in an exhaustive treatment of the subject. The book purports to be a discussion for the general public as well as for a medical audience. While this is true of a few articles, in the main they are above the heads of all but the more scientific-minded of the laymen. It is quite impossible to pick out special articles for praise as practically everyone of them is worthy of notation. The readers of this Journal will doubtless take particular interest and pride in the treatises on sanitary engineering.

Earle B. Phelps in "The Need of Air—Good and Bad Air" succeeds in making his article clear to the layman, although he writes in a thoroughly scientific manner. He concludes with the forceful statement which should bear fruit—"good air is primarily cool air with a moderately low humidity and with sufficient movement and replacement by fresh air from out of doors to provide for the normal cooling of the body."

"Safeguarding the Water We Drink" by John F. Norton is a clear, concise picture of the chemical and bacterial methods of testing and purifying the water supplies of the country. He emphasizes the point that, as far as feasible, an attractive as well as a safe drinking water is highly desirable.

In "The Scientific Disposal of Sewage" John Arthur Wilson tells how this has been accomplished in Milwaukee with great success. Milwaukee has changed an offensive sewage, a menace to health, into a source of pride and wealth to the community. In connection with the disposal plant there are modern chemical research laboratories with investigations under way looking toward continued improvements of the plant and into the basic principles of sewage disposal.

There is but one adverse criticism to make of the whole volume. It is a pity that men interested in public health and hygiene should be so thoughtless of their public as to bring forth a book so poor both in print and paper that it cannot help but ruin the eyes of many who read it.—*L. Liberles.*

Investigations on Watersupply in the Dutch East Indies during 1927. (From the Government Laboratory for Water Hygiene, Manggarai, Batavia) 1928. The bacteriological and chemical investigations in the field and in the laboratory for the water supply of several towns and farms on Java, Sumatra and Borneo are briefly summarized. The report deals with well water, ground water, lake water and river water supplies. Slow sand filtration, mechanical filtration and chlorinating are applied depending on circumstances. The special work concerning this investigation is described in the "Mededeelingen van den Dienst der Volksgezondheid in Nederlandsch Indië, Batavia."